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North Central Forest Experiment Station

General Technical Report NC-138

FIREFAMILY 1988

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FS INFO-Intermountain
MONTHLY ALERT
Edition JUN - - 1990
Item No. 374
File SD 11 .A3575 no. 138

Note to the Reader

The 1988 version of the National Fire-Danger Rating System (NFDRS) will be field tested in 1990. If changes occur as a result of these tests, there may also be some changes in FIREFAMILY. We therefore advise you to watch for possible NFDRS and FIREFAMILY revisions in 1991.

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1992 Folwell Avenue
St. Paul, Minnesota 55108
Manuscript approved for publication March 15, 1990
1990

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FIREFAMILY 1988

William A. Main, Donna M. Paananen, and Robert E. Burgan

One of the missions of wildland fire management is to integrate fire with other land management activities to achieve desired objectives at the lowest cost. When fire managers know how fires are likely to behave in an area as well as that area's associated weather, topography, and fuel moistures, they can establish limits for public and industrial activities, plan prescriptions for burning, pre-position and dispatch suppression resources, and select appropriate wildfire suppression tactics. This publication and its predecessor (Main *et al.* 1982) show fire managers how to employ FIREFAMILY, a computer program that uses historic weather data to predict future fire management needs.

FIREFAMILY 1988 has been revised to reflect changes resulting from the 1988 revisions to the National Fire-Danger Rating System (NFDRS) (Burgan 1988). The changes, made at the request of the fire management community in the Eastern United States, provide the following improvements:

- An increased drought response in humid environments.
- More flexibility to reflect greening and curing of live fuels.
- A better estimate of fire danger in the autumn.
- A better estimate of fire danger following precipitation.
- A new set of 20 fuel models to implement the changes.

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These changes enable fire managers either to use the system nearly unaltered from the 1978 NFDRS or to select those modifications that address their local problems.

The three major routines of FIREFAMILY are FIRDAT, SEASON, and FIRINF. In the routine FIRDAT, fire weather station characteristics are combined with daily weather records and the equations of the NFDRS to produce **frequency distributions tables** and **graphs** of the NFDRS indexes and components. These **frequency tables** and **graphs** are useful for determining manning levels. For an explanation of the NFDRS, see Deeming *et al.* (1977), Burgan *et al.* (1979), Burgan (1988), and Helfman *et al.* (1987). SEASON and FIRINF re-read data created by FIRDAT and organize it into probabilities, seasonal graphs, calendars, and other fire management tools.

In the following sections, we discuss each of these three major routines, emphasizing what you will be required to provide as well as how you can analyze the various products. We also provide an Appendix to acquaint you with the Fort Collins Computer Center (FCCC) job-control language required to operate this program. Because FIREFAMILY continually grows to meet users' needs, you might notice slight differences between the output used for illustration and that received from the Fort Collins computer. For updated instructions, contact the USDA Forest Service, Fire and Aviation Management Staff, P.O. Box 96090, Washington, DC 20090-6090.

FIRDAT ROUTINE

FIREFAMILY has been revised to permit processing of all historical weather records in the Fire Weather Data Library with either 1978 or 1988 NFDRS fuel

models. Appendix IV provides computational details for using pre- and post-1988 style weather data with either fuel model set. Required changes in the program operation are defined in this publication.

You will begin the analysis of your data by providing information to FIRDAT on lead cards. This information includes the station's elevation, latitude, fuel model, slope class, herbaceous type, shrub type, beginning Keetch-Byram Drought Index value, beginning 1,000-hour timelag fuel moisture, average annual precipitation, and climate class (see Appendix I). FIRDAT will read this information as well as your historical weather data on file at the National Fire Weather Data Library (NFWDL) (see Furman and Brink 1975).

FIRDAT examines your weather data on a daily basis to determine the best option to use in computing the daily fuel moistures. Then, using the NFDRS equations, FIRDAT calculates the NFDRS components and indexes. These daily values of weather, indexes, and components can be saved for later use; they **must** be saved if you are going to use SEASON and/or FIRINF. You can request a printout of these values called the **daily list**.

An innovative aspect of this routine allows you to define the specific dates for a fire season for a particular protection area. This feature is especially helpful if you have a split fire season. In the Northeast, for example, fires occur frequently in both the spring and the fall, but few fires occur in the summer. You might select April 10 as the beginning of the fire season and November 9 as its end on lead card one (Appendix Ia). Then on lead card two (Appendix Ib), you would exclude the summer period from June 21 to September 11 when there are few fires. FIRDAT would then provide a frequency analysis for only the high risk spring and fall periods.

FIRDAT always prints a **summary of station statistics** for each year you select. When the data for your station end, the routine prints **frequency distributions tables** and **graphs** for those NFDRS indexes and components you chose on lead card one.

Header Page

FIREFAMILY always prints a **header page** (fig. 1) showing the information you supplied on your lead cards. Always keep your **header page** attached to the output as a permanent record of the input you used for that run. The **header page** repeats (character-by-character) the information you supplied. The program then inspects your lead cards for consistency and format. For instance, if the weather information read by the computer is not for your station, or is outside the years that you specified on your lead card, you will receive an error message.

The large block number 240107 on our **header page** (fig. 1) is the weather station number. Bold letters **A** and **B** point out the information supplied on the FIRDAT lead cards. Letter **C** identifies a SEASON lead card and letter **D** identifies a FIRINF lead card. Note that you can provide up to three separate lead cards for both SEASON and FIRINF.

The routine prints a KEY line under the CARD line to identify the entries immediately above it.
Find ! = PASSING FILE on lead card one. The KEY character "!" is associated with the **passing file**, an essential FIREFAMILY component that passes FIRDAT data to SEASON and FIRINF. Now find the "!" in the KEY line. Look directly above the "!" and find a "T" **(E)**. The "T" stands for true, indicating that a **passing file** was created in this run. An "F" (false) in the CARD line would mean that the **passing file** was not created and is not available for use with SEASON and FIRINF.

Daily List

If you choose to print the weather data, the routine will print the **daily list** (fig. 2). Always examine your **daily list** closely to ensure that the historical weather elements correspond to your original weather records.

At the top of each page, the title "DAILY LIST" appears. Included on the left are the FIREFAMILY version number—"1988 NFDRS VERSION FFY 3.0," the administrative ownership—"KOOTENAI NF," the station name and number—"LIBBY MONTANA 240107," and the user-selected MODEL-"8C," SLOPE CLASS-"2," HERB TYPE-"A," SHRUB TYPE-"E," and CLIMATE CLASS-"2." Model 8C refers to the 1988 NFDRS fuel model C. A 7C designation would refer to the 1978 NFDRS fuel model C. Included on the right are the date of the run, page number, station elevation and latitude, and the fire season dates.

Bold **A** indicates abbreviated column headings. From left to right, these abbreviations stand for: date of observations; season of the year; processing option; state of the weather; dry-bulb temperature; relative humidity; wind speed; maximums and minimums of temperature and relative humidity; amount and duration of precipitation; lightning activity level; human-caused risk; the six fuel moistures: woody and herbaceous with their associated greenness factors, 1-hour,

```
  2222          44      000000       11       000000    77777777
22222222   44   44      000000      111       000000    77777777
22    22   44   44     00    00    1111      00    00        77
      22   44   44     00    00   11111      00    00        77
     22    44   44     00    00      11      00    00       77
    22     44   44     00    00      11      00    00       77
   22      44   44     00    00      11      00    00      77
  22       44444444    00    00      11      00    00      77
 22        44444444    00    00      11      00    00     77
22               44    00    00      11      00    00     77
22222222         44     000000   11111111    000000     77
22222222         44     000000   11111111    000000     77
```

A .LEAD CARD ONE PROVIDES THE STATION DESCRIPTION AND CONTROLS FOR FIRDAT. **E**

```
.
CARD.1KOOTENAI NF LIBBY MONTANA        240107 2070498C2AE2F7277 5 9 9 9TTTTTTTTTTFFT
KEY . , UNIT NAME,,    STATION NAME    ,,NMBR,,ELV,LLMMSHSC1,YR,,BGNEND,12345678FD+W!
    .ELV= ELEVATION ,'LL-MM-S-H-S-C-1= LATITUDE,MODEL,SLOPE,HERB TYPE,SHRUB TYPE,CLIMATE,1 HR = 10 HR,YR= YEARS
    .BGNEND=FIRE SEASON DATES,1-8=SELECTED FREQ DIST.,F=MOIST FREQS,D=DAILY LIST,+=NO FIRDAT,W=LIST WEATHER ONLY,!=PASSING FILE.
```

B .LEAD CARD TWO PROVIDES ADDITIONAL CONTROLS.

```
.
CARD.2 1.00 12 12 6 1 910 20.3  020  0  0  0  0  0  0  0  0   0   069097
KEY . (LRS)  W  E(GU)(FR) PPT KDITHMMSHSCMMSHSCMMSHSCMMSHSC(LOW-HI)F1%2%
    . (LRS)= LIGHTNING SCALING FCT, HUMAN RISK W= WEEKDAY, E= WEEKEND (GU)= GREENUP MONTH-DAY,(FR)= FREEZE,
    .PPT= AVERAGE ANNUAL PRECIP, KDI= STARTING KEETCH-BYRAM DROUGHT INDEX, TH=STARTING 1000 HOUR FUEL MOISTURE
    .MMSHSC= MODEL-SLOPE-HERB-SHRUB-CLIMATE, (LOW-HI)= SKIP PERIOD, F= FILL SEA & INF ARRAYS, 1%2%= MANNING PERCENTILES.
```

C .LEAD CARD THREE MAY BE REPEATED UP TO 3 TIMES, AND PROVIDES THE CONTROL FOR SEASON.

```
.
CARD.3112345670TT 5F6  0  0  0  0  0  0T  0   .0  .00
KEY . L12345678GT()YP,6 PERST DIVISNS ,B90% EXBI,EXDY
    .L= VARIABLE LIST, 1-8= SELECTED VARIABLES, G= GRAPHS, T= TABLES, ()= AVERAGING PERIOD,
    .Y= SINGLE YEARS ,P= PERSIST INDEX, B= BI SEVERITY,
    .90%= BI PERCENTILE VALUE, EXBI= AV.BI SUM, EXDY= AV.DAYS GREATER THAN 90%
```

D .LEAD CARD FOUR MAY BE REPEATED UP TO 3 TIMES, AND PROVIDES THE CONTROL FOR FIRINF.

```
.
CARD.4TF0  0  0  0  0  0  0  0  0  0  00  0  0  0  0  0  0  0  0  0  0
KEY . APX,    TEN HORIZ DIVISIONS     ,Y,    TEN VERTC DIVISIONS     ,
    .A= ADJECTIVE CLASS, P= PRECAUTIONS CLASS, X= HORIZONTAL INDEX, Y= VERTICAL INDEX.
```

Figure 1.–*Header page.*

1988 NFDRS VERSION FFY 3.0 DAILY LIST 27 OCT. 89 PAGE 2
KOOTENAI NF LIBBY MONTANA 240107 ELEVATION- 2070 LATITUDE-49
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2 FIRE SEASON- 5/ 9 TO 9/ 9

A

DY	S	O P	S W	D B TMP	REL HUM	WD SP	TEMP MAX	TEMP MIN	RH MAX	RH MIN	PRECIP AMNT	PRECIP DUR	LAL	HUM RSK	WOODY FM	WOODY GF	HERB FM	HERB GF	1 HR	10 HR	100 HR	1000 HR	KDI NDX	IGN COM	SPD COM	ENR COM	HOI NDX	LOI NDX	BUR NDX	FLI NDX
MAY					1972																									
1	0	1	1	62	23	3	64	19	99	20	.00	0	1	12	60	0	5	0	5	10	15	20	2	11	2	14	1	0	13	9
2	0	1	1	67	43	0	70	25	99	20	.00	0	1	12	60	0	8	0	8	13	14	19	5	5	1	10	1	0	9	6
3	0	1	1	60	55	0	70	26	66	22	.00	0	1	12	60	0	10	0	10	14	12	19	8	4	1	9	0	0	8	6
4	0	1	2	62	51	3	70	31	99	30	.00	0	1	12	60	0	10	0	10	14	13	19	11	4	2	9	0	0	10	7
5	0	1	2	62	43	0	70	41	99	40	.00	0	1	12	60	0	9	0	9	13	14	18	14	4	1	10	0	0	9	6
6	0	1	2	59	36	0	64	39	99	36	.00	0	1	12	60	0	8	0	8	13	14	18	16	5	1	10	1	0	9	6
7	0	1	2	60	50	0	66	37	99	30	.00	0	1	12	60	0	10	0	10	14	14	18	18	3	1	9	0	0	8	6
8	0	1	6	50	81	0	67	43	100	42	.04	1*	1	12	60	0	18	0	20+	22	15	18	20	0	0	0	0	0	0	0
9	0	1	2	52	76	0	56	40	99	52	.35	2*	1	12	60	0	20	0	20	20	16	18	2	0					0	0
10	0	1	3	59					99	52	.00	0	1	12				0	15	15	16	18								
						2	87	38																	2	15	2	0		
30	0			91	26	0	93	42	99	22				12	60	0	5	0					100	13	1	16	2	0	12	9
31	0	1	9	75	63	3	85	49	99	32	.10	1*	1	12	60	0	12	0	12	14	13	16	109	3	1	7	0	0	9	6
D 31											.82	9		372									1218	192	44	301	22	0	304	216
JUNE					1972																									
1	0	1	1	79	27	4	82	44	99	27	.29	2*	1	12	65	0	17	0	9	9	14	16	97	6	2	12	1	0	12	9
2	0	1	1	82	19	3	82	36	99	19	.00	0	1	12	69	0	24	0	8	8	13	15	104	7	2	13	1	0	12	9
3	0	1	1	76	36	1	80	46	99	22	.00	0	1	12	73	0	30	0	7	11	13	15	110	7	1	12	1	0	10	7
4	0	1	1	78	26	2	80	36	99	26	.00	0	1	12	77	0	36	0	5	9	13	15	116	11	1	14	1	0	12	9
5	0	1	0	85	27	4	87	37	99	18	.00	0	1	12	81	0	43	0	5	9	13	15	125	13	2	14	2	0	13	9
6	0	1	0	91	18	3	93	37	99	12	.00	0	1	12	85	0	49	0	4	7	12	15	137	15	2	16	2	0	13	9
7	0	1	3	76	46	5	81	54	99	38	.00	0	1	12	88	0	58	0	9	12	13	15	143	5	1	8	1	0	9	6
8	0	1	3	75	63	3	75	56	99	48	.16	1*	1	12	92	0	67	0	14	14	14	15	146	1	1	3	0	0	4	3
9	0	1	2	71	73	2	78	57	99	48	.20	1*	1	12	97	0	76	0	16	16	14	15	135	0	0	2	0	0	2	1
10	0	1	9	80	33	3	82	56	99	22	.45	2*	1	12	102	0	81	0	9	9	14	15	97	3	1	7	0	0	7	5
11	0	1	3	47	93	0	60	44	99	42	.55	3*	1	12	109	0	96	0	30	30	16	16	43	0	0	0	0	0	0	0

B **C** **E**

(* = DURATION OR 10HR MOISTURE WAS CALCULATED. T = TRACE OF PRECIP. + = RAINING AT OBS TIME.)

Figure 2.–*Daily list.*

10-hour, 100-hour, and 1,000-hour; the Keetch-Byram Drought Index; three NFDRS components: ignition, spread, and energy release; four NFDRS indexes: human-caused fire occurrence, lightning-caused fire occurrence, burning, and fire load. Because this example illustrates processing of 1978 NFDRS weather data with a 1988 NFDRS fuel model, season and greenness factor data are not available, so these values are defaulted to 0.

Three special symbols may appear in the printout. A star "★" **(B)** after either the precipitation duration or the 10-hour fuel moisture indicates that these values were computed rather than read from the data. A plus sign "+" **(C)** after the 1-hour fuel moisture shows that it was raining at observation time. A "T" after a zero ".00" in precipitation amount would indicate a trace. A key to this information appears at the bottom of each **daily list** page.

At the end of each month, FIRDAT produces a summary report **(D)** of the number of days in the month, the precipitation amount and duration, and the human-caused risk level. The NFDRS indexes and components are also totaled. This report may be used to chart the monthly progress of your fire season. The **daily list** also provides a convenient way to learn how changing weather elements affect the fuel moistures and the NFDRS values. It is a complete statement of all that is known from a fire-danger point of view about any particular day, and it can provide information for fire reviews, trespass cases, arson investigations, and other studies when no other measurements were made.

In addition, fire managers who study the **daily list** might also see sudden changes in the character of a particular element such as woody fuel moisture green-up. Note that before green-up on June 1 **(E)**, the woody fuel moisture was held constant, and the herbaceous fuel moisture was the same as the 1-hour fuel moisture. At green-up, the living fuel moistures begin to increase.

Summary of Station Statistics

The **summary of station statistics** (fig. 3) is printed after each year is processed. The usual heading appears at the top of the page with the title. The year **(A)** for which these data are being summarized is printed below the title. This printout summarizes the lightning fire occurrence indexes for the fire season **(B)** using a lightning scaling factor **(C)** specified on lead card two. The summary also illustrates the pattern of lightning activity level distribution **(D)**. These statistics are required to recalculate the lightning scaling factor for use with the AFFIRMS program. (See Appendix D of Deeming *et al.* 1977 for a discussion of this analysis.) FIRDAT reports how much data were missing from the official fire season **(E)** and the total number of days processed **(F)**.

The average ignition component is printed to help the fire manager appraise the local adjustment for human-caused fires **(G)**. (See Deeming *et al.* 1977, Appendix E.) If you have selected the **passing file** (a product of FIRDAT that passes data to SEASON and FIRINF), the total number of records written on it will be noted at the bottom of the final annual summary that you receive **(H)**.

Frequency Distributions Table

FIRDAT sorts all the days in a station's fire season from the lowest to the most extreme fire danger and prints out a **frequency distributions table** (fig. 4). On lead card one you select the indexes, components, and/or fuel moistures for tabulation. You will receive a table for each variable that you select. The table summarizes how often each level of that measure of fire danger occurred.

In our example, the burning index **(A)** was the chosen variable. Our table shows the total number of days (743) that fell within the fire season **(B)** and the total number of classes (14) into which the variable is divided **(C)**. To ensure that this table will fit on one page, FIRDAT limits the number of classes to 50. In our example, the BI could range from 0 to 100, so the routine automatically chose a step size of two **(D)**. The sequence is detailed in the upper boundary column.

The first column of this table shows class (or row) numbers. The first row of the table (CLASS NO. 1) gives the number of days with a BI of zero. (When it is raining, fire weather observers enter zero values in their weather logs.) In this example, because the step size is 2, the second row (or CLASS NO. 2) includes days that had burning indexes of 1 and 2 with an upper boundary of 2 **(E)**. The next column **(F)** tells how many days were at those levels of the BI. The relative frequency column **(G)** indicates that the 44 days in row two make up 5.9 percent of the total number of days.

Many agencies use the cumulative frequency **(H)** as the basis for determining their adjective levels or manning classes. Cumulative frequency is the percent of all the days in the fire season that had as small a

1988 NFDRS VERSION FFY 3.0 SUMMARY OF STATION STATISTICS 27 OCT. 89 PAGE 36
KOOTENAI NF LIBBY MONTANA 240107 ELEVATION- 2070 LATITUDE-49
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2 FIRE SEASON- 5/ 9 TO 9/ 9

1977 **A**

T O T A L OF LIGHTNING OCCURRENCE INDEXES FOR THE FIRE SEASON OF 5/ 9 - 9/ 9 LESS 0- 0 IS -- 191 **B**

WITH A LIGHTNING SCALING FACTOR OF 1.00 **C**

LIGHTNING ACTIVITY LEVEL DISTRIBUTION

LAL CLASS	NO IN CLASS	PCT FREQ	FREQUENCY DISTRIBUTION
1	56	45	**********
2	51	41	**********
3	12	10	*********
4	4	3	***
5	1	1	*
6	0	0	

D

W E A T H E R O B S S C O R E

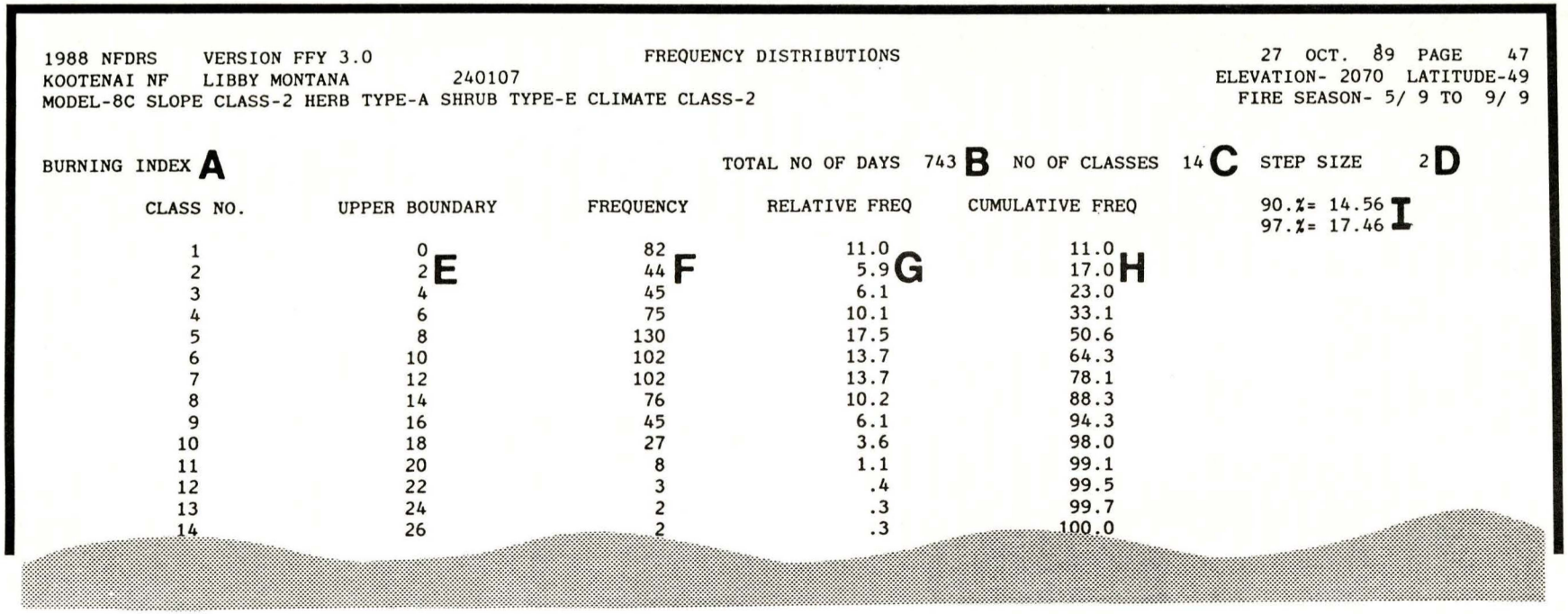
YOU RECORDED WEATHER FOR A TOTAL OF 124 OUT OF A POSSIBLE 124 DAYS
DURING YOUR DEFINED FIRE SEASON. YOU L O S T 0 PERCENT OF YOUR DATA **E**

A TOTAL OF 214 DAYS WERE PROCESSED IN AND OUT OF THE FIRE SEASON. **F**

AVERAGE IGNITION COMPONENT FOR THE DEFINED FIRE SEASON IS -- 7 **G**

AT THIS POINT IN THE RUN 1113 RECORDS HAVE BEEN WRITTEN TO THE PASSING FILE. **H**

Figure 3.–*Summary of station statistics.*



1988 NFDRS VERSION FFY 3.0 FREQUENCY DISTRIBUTIONS 27 OCT. 89 PAGE 47
KOOTENAI NF LIBBY MONTANA 240107 ELEVATION- 2070 LATITUDE-49
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2 FIRE SEASON- 5/ 9 TO 9/ 9

BURNING INDEX A TOTAL NO OF DAYS 743 B NO OF CLASSES 14 C STEP SIZE 2 D

90.%= 14.56 I
97.%= 17.46

CLASS NO.	UPPER BOUNDARY	FREQUENCY	RELATIVE FREQ	CUMULATIVE FREQ
1	0	82	11.0	11.0
2	2 E	44 F	5.9 G	17.0 H
3	4	45	6.1	23.0
4	6	75	10.1	33.1
5	8	130	17.5	50.6
6	10	102	13.7	64.3
7	12	102	13.7	78.1
8	14	76	10.2	88.3
9	16	45	6.1	94.3
10	18	27	3.6	98.0
11	20	8	1.1	99.1
12	22	3	.4	99.5
13	24	2	.3	99.7
14	26	2	.3	100.0

Figure 4.–*Frequency distributions table.*

value as the one indicated in the upper boundary column. In row two, for example, 17.0 percent of the 743 days in the fire season had burning indexes of 2 or less. Often, fire managers determine their manning levels at two specific percentile values. You can specify these two values on lead card two. FIRDAT will use 90th and 97th percentiles **(I)** unless you enter different ones. Our example indicates that the BI has a value of 15 (14.56, rounded up), or less, 90 percent of the time in the fire season. Similarly, the fire manager would expect the BI to be 17 (17.46, rounded down) at least 97 percent of the time. On the other 3 percent of the days, the burning index will exceed 17.

Frequency Distributions Graph

The points on the **frequency distributions graph** (fig. 5) are the cumulative frequencies listed in the last column of the **frequency distributions table** (fig. 4). This graph allows you to find the cumulative percentage of days in your fire season that any value of the chosen variable exceeds. In our example, the vertical line drawn at the 50th percentile **(A)** intersects the **frequency distributions graph** near the BI of 8. Thus, on half of the days in the fire season, the BI will be approximately 8 or less.

Manning Class Table

Frequency distributions are often used to determine agency manning classes. One method for calculating the upper boundaries for six manning classes is shown in table 1[1]. We used our **frequency distributions table** (fig. 4, **I**) to find the upper boundaries for the 90th and 97th percentiles of the BI. Then we divided the 90th percentile value (15) according to the formulas shown to obtain the upper boundaries of the other classes. Remember that the lower boundary of the lowest range is 0, but the upper boundary of the extreme range is limited only by the index or component selected.

[1] *See Appendix E of the AFFIRMS manual (Helfman* et al. *1987) for an example of a 10-manning class table.*

Observed Weather Elements

FIREFAMILY allows you to request a printout of **observed weather elements** (fig. 6). (Note: choosing this feature will suppress all other FIREFAMILY features.) The column headings **(A)** are similar to those in the daily list, except that no fire-danger rating values are calculated or printed. This is the only FIREFAMILY listing that shows how the relative humidity was measured **(B)**. In our example, RH indicates that the relative humidity was measured directly rather than estimated from a wet-bulb or a dew point temperature. This printout is also the only one that shows the wind direction **(C)**.

FIRDAT Lead Card One

The information that the fire manager provides on the lead cards is vital to the success of FIREFAMILY routines. Every time FIREFAMILY is run, you must provide lead cards one and two. The options you choose will determine the results obtained as well as the costs of running the program.

Lead card one (Appendix Ia) already has been coded with a 1 in the first card column. Continue by coding with the administrative owner's name, station name and number, elevation in feet, and latitude. For example, KOOTENAI NF; LIBBY MONTANA; 240107; 2070 feet; and 49° were coded in card columns 2-46.

Table 1.–An example of a 6-manning class table

Manning class	Description	Burning index	Calculation formulas	Upper boundaries of manning classes
6	Extreme	18+	Above the 97th percentile	(100+)
5	Very high	16-17	97th percentile (from table)	17
4	High	12-15	90th percentile (from table)	15
3	High moderate	8-11	90th percentile/1.33 = 10.95	11
2	Low moderate	5-7	90th percentile/2 = 7.28	7
1	Low	0-4	90th percentile/4 = 3.64	4

NOTE: The lower boundary in each manning class is one more than the upper boundary of the next lowest class. Set the upper boundary of the extreme class high enough to accommodate the most extreme value of your variable.

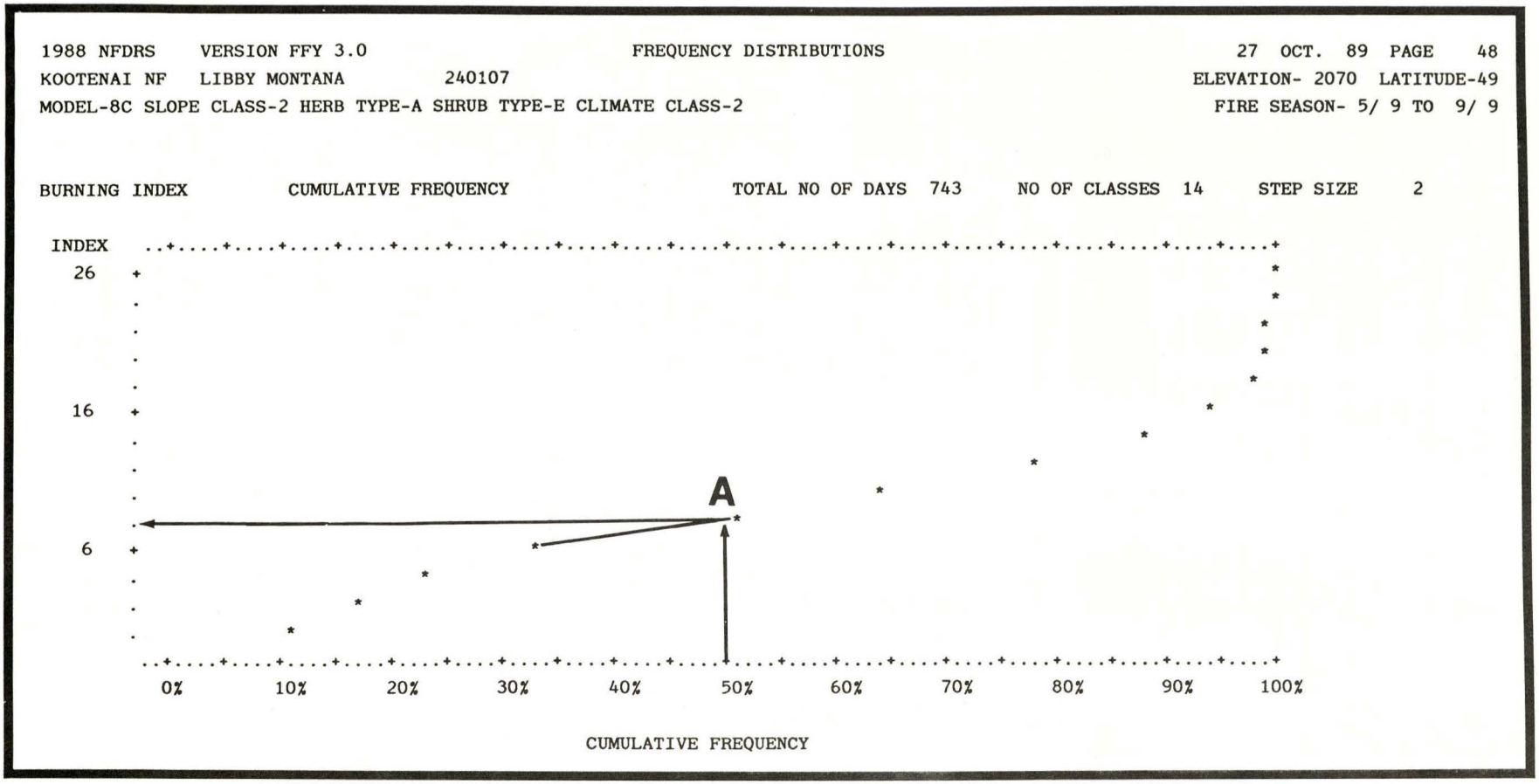


Figure 5.–*Frequency distributions graph.*

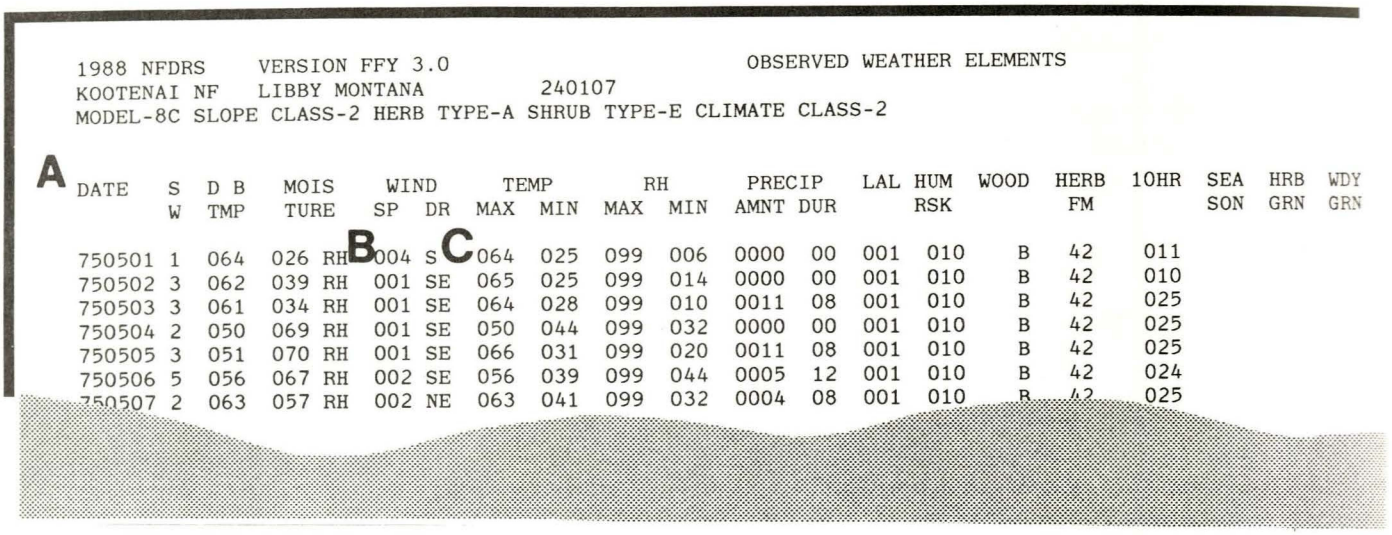


Figure 6.–*Observed weather elements.*

Next, you must specify a model-slope-herb-shrub-climate class combination. The model designation now requires two characters. The first character should be a 7 or an 8 to select a model from the 1978 or the 1988 fuel model set. The second character is the fuel model letter. Ordinarily this will be the same combination you use for your daily weather observations. Coding a T in column 53 will always set the 1-hour fuel moisture equal to the 10-hour fuel moisture. If you code an F in column 53, the 1-hour and 10-hour fuel moistures will be equal only on the day of and the day after rain. You should use all of the weather data available to you at the National Fire Weather Data Library. If you code 00 for the beginning of the range of years and 99 for the ending year in item 9, you will obtain output for all of your station's historic weather data.

FIRDAT allows you to specify the beginning and ending months and days of your fire season in item 10. Your fire season may begin in the fall and end in the spring or vice-versa. Note: You may skip over periods of low fire danger by specifying them on lead card two, item 9.

At this point, your selections on lead card one become even more important. For example, if you choose all the available variables, you will generate excess paper. If you choose only the variable or variables your agency uses for planning, your FIREFAMILY run will be quicker. You may choose up to nine variables in item 11 (columns 66-74): ignition component, spread component, energy release, human-caused fire occurrence, lightning-caused fire occurrence, burning index, fire load index, Keetch-Byram Drought Index, and/or fuel moistures. Code a "T" (true) in the appropriate column for each variable you want to see. Place an "F" (false) in the columns of the variables you don't want. If you code a "T" for dead fuel moistures, you will get all four: 1-hour, 10-hour, 100-hour, and 1,000-hour.

Next, you should decide if you wish to see the **daily list** of weather, components, and indexes. Place a "T" in column 75 to see the **daily list**. If you have already seen the **daily list**, placing an "F" in column 75 will save you money. Coding an "A" (for all combinations) will be expensive because it will cause the routine to print **daily lists** for all of the model-slope-herb-shrub-climate combinations that you select on lead card two.

The most important dollar-saving feature of FIREFAMILY is its ability to skip over FIRDAT when you have saved your **passing file** from a previous FIRDAT run. Code "T" in column 76 to skip FIRDAT and go directly to SEASON and/or FIRINF. Placing an "F" in column 76 will cause normal FIRDAT operation.

Placing a "T" in column 77 activates the weather-only feature (**observed weather elements**—fig. 6) of FIREFAMILY. Always place an "F" in column 77 unless you want only the raw weather data.

Placing a "T" in column 78 will cause the program to create a **passing file** (the file that passes information to SEASON and FIRINF). Because it is expensive to create the information on the **passing file**, you should save this file for later use with FIRINF and/or SEASON.

FIRDAT Lead Card Two

Lead card two (Appendix Ib) gives you other FIRDAT options. You can provide information about risk assessments, dates for green-up and curing, average annual precipitation, beginning Keetch-Byram Drought Index and 1,000-hour fuel moisture, up to four additional combinations of model-slope-herb-shrub-climate, and you may specify a split fire season. If you are going to run SEASON and FIRINF together with FIRDAT, you may also redefine the upper boundaries of your manning percentiles on lead card two.

If you don't know your lightning risk scaling factor (LRS), use the value 01.00 in columns 2-6 of lead card two. If you run FIRDAT again, you should consult Deeming *et al.* (1977, Appendix D) to review guidelines for computing the lightning risk scaling factor. (See fig. 3, **B**, to find the total of lightning occurrence indexes in our example.)

You must provide estimates on lead card two for weekday and weekend human risk. The weekday (W) and weekend (E) values may range from 0 to 100 and should be recorded in columns 7-9 and 10-12.

If all your weather data include season and herb/woody greenness factors, you do not need to code columns 13-20 and you may skip to the next paragraph. However, if some of your weather data do not include season and herb/woody greenness factors, you must select the month and day when herbaceous plants usually start to green-up at your station. Code the month in card columns 13-14 and the day in 15-16. (Key abbreviation for green-up on lead card two in fig. 1 is GU.) Continue by specifying the earliest month and day on which you expect fall curing to begin. Herbaceous plants will not necessarily die on this day; instead FIRDAT begins to look for weather conditions that indicate freezing. If, for instance, a hard frost occurs with a minimum temperature of 25° or less, the NFDRS will "cure" the herbaceous fuels immediately. If no hard frost occurs, FIRDAT automatically records curing and dormancy after the fifth day with a minimum temperature of less than 33°. If minimum temperatures were not observed for your station, the date you specified in columns 17-20 will be used as the curing date. If your area never experiences freezing, enter 1232 in columns 17-20.

The average annual precipitation, entered in columns 21-24, is used to calculate the Keetch-Byram Drought Index. Enter the value for rain plus the water equivalent of snowfall.

Enter zero in columns 25-27 for the beginning Keetch-Byram Drought Index if weather observations normally begin when the soil is still fully moist. Burgan (1988) provides a table to estimate a beginning Keetch-Byram Drought Index if weather observations normally begin after significant soil drying has occurred.

The default 1,000-hour fuel moisture depends on the climate class assigned to the station—15, 20, 25, or 30 for climate classes 1, 2, 3, or 4, respectively. You must enter one of these default values in columns 28-29, or you can enter an estimate of your own. For example, if weather data collection normally begins after significant drying has occurred, you may wish to enter a value lower than the default value.

Because of diverse fuel types and topography, you might want to process your data with more than one combination of model-slope-herbaceous class-shrub type-climate. If so, indicate as many as four additional combinations in card columns 30-53. For example, if you have two different forest types near your weather station, you could process the data for upland hardwood stands (NFDRS Model 8E) and, with the same set of lead cards, process the conifer types (NFDRS Model 8H). If, on lead card two, you change your climate class, shrub type, or herbaceous code, you may have to use a new lead card one to redefine the green-up and curing dates.

Many areas of the country have a two-part fire season. The Southeast, for example, has a fall season of October and November and a spring season of February to April. With that pattern, running cumulative frequencies for dates from October to April will include the 2 months of low fire occurrence (December and January), thereby biasing the results. To avoid this bias, skip the low risk period by coding its beginning month in columns 54-55, the beginning day in columns 56-57, the ending month in columns 58-59, and the ending day in columns 60-61. If you do not have a split fire season, leave these columns blank.

The first time you use FIREFAMILY, you should run FIRDAT by itself, saving the **passing file**. You can then analyze the FIRDAT cumulative frequency tables to find the index values necessary to calculate your manning classes. If you want to include SEASON and/or FIRINF in the first run, FIRDAT provides an option that calculates a set of ranges for one index. Choose the number of the variable (1-8) from the list in item 10 and code it in card column 62 (see Appendix Ib). This code will cause FIRDAT to calculate the ranges that will become the rows and/or columns for

your SEASON and FIRINF tables. **However, we strongly recommend that you do not attempt to run SEASON or FIRINF in the first run with FIRDAT.**

The USDA Forest Service uses the 90th and 97th percentiles to delineate the high and very high manning classes. If your agency uses other values, you should enter them in columns 63-64 and 65-66 on lead card two.

SEASON ROUTINE

The severity of fire weather varies during the year. The SEASON routine summarizes these variations and reveals seasonal patterns over many years to help fire managers plan. SEASON will tabulate and/or graph the values of any of the fuel moistures, indexes, or components the fire manager wishes to analyze.

SEASON has three major sections: **seasonal tables** and **graphs**, monthly **persistence probability tables**, and the cumulative **BI seasonal severity list** and **summary table**. The **seasonal tables** show the average, highest, and lowest values of the chosen variable for each day of the year. **Seasonal graphs** map the general character of the fire season shown in the **seasonal tables**. The **persistence probability tables** report the chance that tomorrow's variable will be the same as today's. The **BI seasonal severity summary table** ranks the fire seasons of each year according to their difficulty, based on the 90th percentile of the burning index. Remember that BI severity measures only the effect of weather, not fire activity.

Seasonal Table

The **seasonal table** shows—for each variable you select—the mean, maximum, and minimum values for the averaging period as well as the number of weather observations recorded over the period of years indicated at the top of the table (fig. 7). All the observed data are included in the **seasonal table**, not just the data from the fire season. To save money and paper, choose only the variable(s) most important for planning.

In figure 7, we chose the BI **(A)**. We also selected an averaging period of 5 days **(B)**. This running mean is an average calculated from an odd number of consecutive days, centered on the observation date. The longer the period chosen for the running mean, the smaller the day-to-day changes in the average will be. This "smoothing" of the daily averages will make a graph of this information easier to interpret. Smoothing periods of 3 to 7 days are usual.

Graphing Options

SEASON provides the option for graphing the tabulated information in figure 7. If you ask for such a graph (Appendix Ic, card column 11 = T), you will get one page of printout for every 2 months shown in the table. You will also receive a graph legend that explains symbols used, years included, and the scale the computer selected to lay out the graph.

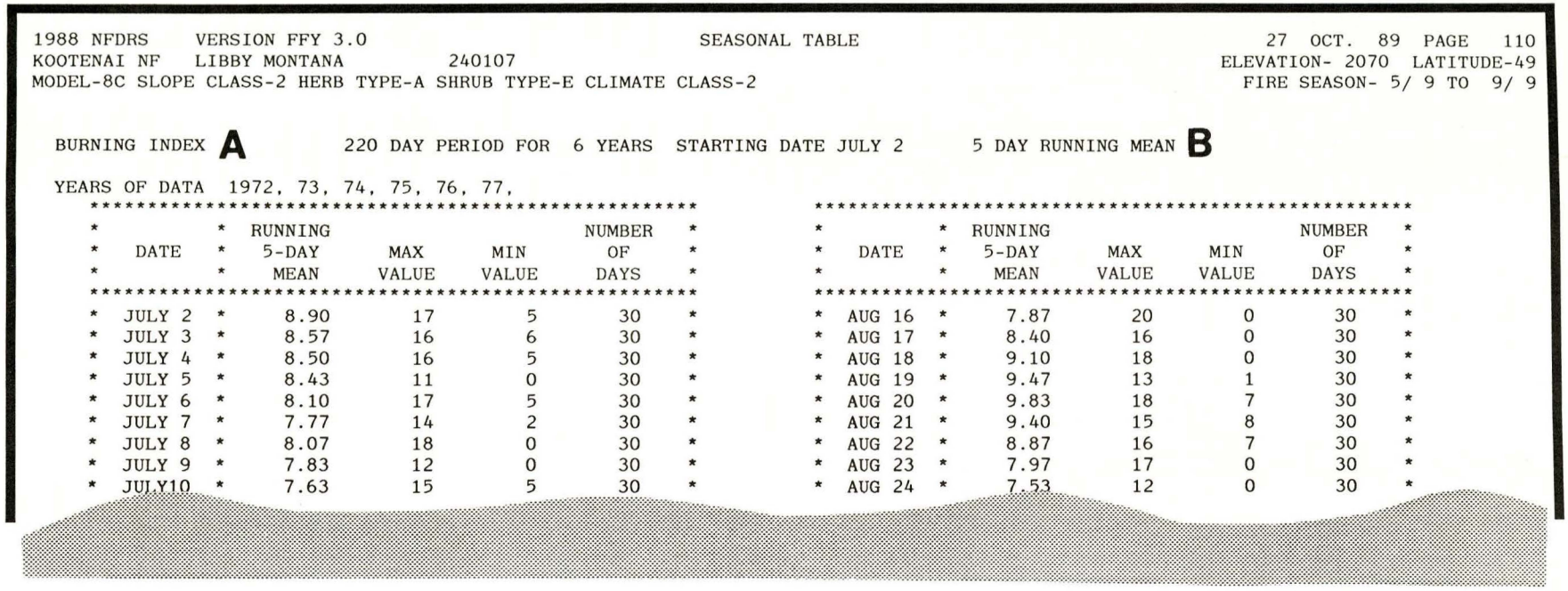
SEASON can also graph the data 1 day at a time, year after year. This feature might give you insight into a particularly bad year or show how drought affects out-of-season wildfires. **Be careful, however, because this feature can generate massive volumes of paper**. To save paper and money, select the variable or variables of greatest concern (columns 3-10, Appendix Ic), use the combination of model-slope-herb-shrub-climate on lead card one only, and turn off the SEASON tables (column 12 = F). To activate this **single year graph** feature, code column 15, lead card 3, with a "T."

Fire Manager's Graph

You can easily construct a graph of your own data. Figure 8 is a graph of the seasonal variations of the BI. You can use graph paper that includes a year-by-day legend along the bottom. To find the range of the variable that we were plotting, we consulted our **frequency distributions table** (fig. 4). Because the upper boundary of the 97th percentile was 17.46, we used 0-17 as the range for our vertical scale. We used the upper boundaries of the 90th and 97th percentiles as well as the information contained in table 1 to draw five horizontal manning class lines. Bold **A** (fig. 8) shows that we drew the line for the upper boundary of our 90th percentile at a BI of 15 (14.56, rounded up).

Next, we transferred the daily mean values from the **seasonal table** to the graph and connected them with a solid line. The dashed lines indicate that less than 5 years of data was available. (We used a running mean of 5 days to smooth our curve.) This curve shows the seasonal variation in the burning index. Finally, we drew vertical lines at the beginning **(B)** and end **(C)** of our fire season.

You could also plot your daily maximum and minimum values from the **seasonal table**. Once you have used your historical weather data to create your seasonal graph, you can use this graph to compare your current daily values with the averages. Lay a clear plastic sheet over your seasonal graph and plot current observed values on it.



1988 NFDRS VERSION FFY 3.0 SEASONAL TABLE 27 OCT. 89 PAGE 110
KOOTENAI NF LIBBY MONTANA 240107 ELEVATION- 2070 LATITUDE-49
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2 FIRE SEASON- 5/ 9 TO 9/ 9

BURNING INDEX **A** 220 DAY PERIOD FOR 6 YEARS STARTING DATE JULY 2 5 DAY RUNNING MEAN **B**

YEARS OF DATA 1972, 73, 74, 75, 76, 77,

DATE	RUNNING 5-DAY MEAN	MAX VALUE	MIN VALUE	NUMBER OF DAYS
JULY 2	8.90	17	5	30
JULY 3	8.57	16	6	30
JULY 4	8.50	16	5	30
JULY 5	8.43	11	0	30
JULY 6	8.10	17	5	30
JULY 7	7.77	14	2	30
JULY 8	8.07	18	0	30
JULY 9	7.83	12	0	30
JULY10	7.63	15	5	30

DATE	RUNNING 5-DAY MEAN	MAX VALUE	MIN VALUE	NUMBER OF DAYS
AUG 16	7.87	20	0	30
AUG 17	8.40	16	0	30
AUG 18	9.10	18	0	30
AUG 19	9.47	13	1	30
AUG 20	9.83	18	7	30
AUG 21	9.40	15	8	30
AUG 22	8.87	16	7	30
AUG 23	7.97	17	0	30
AUG 24	7.53	12	0	30

Figure 7.–*Seasonal table.*

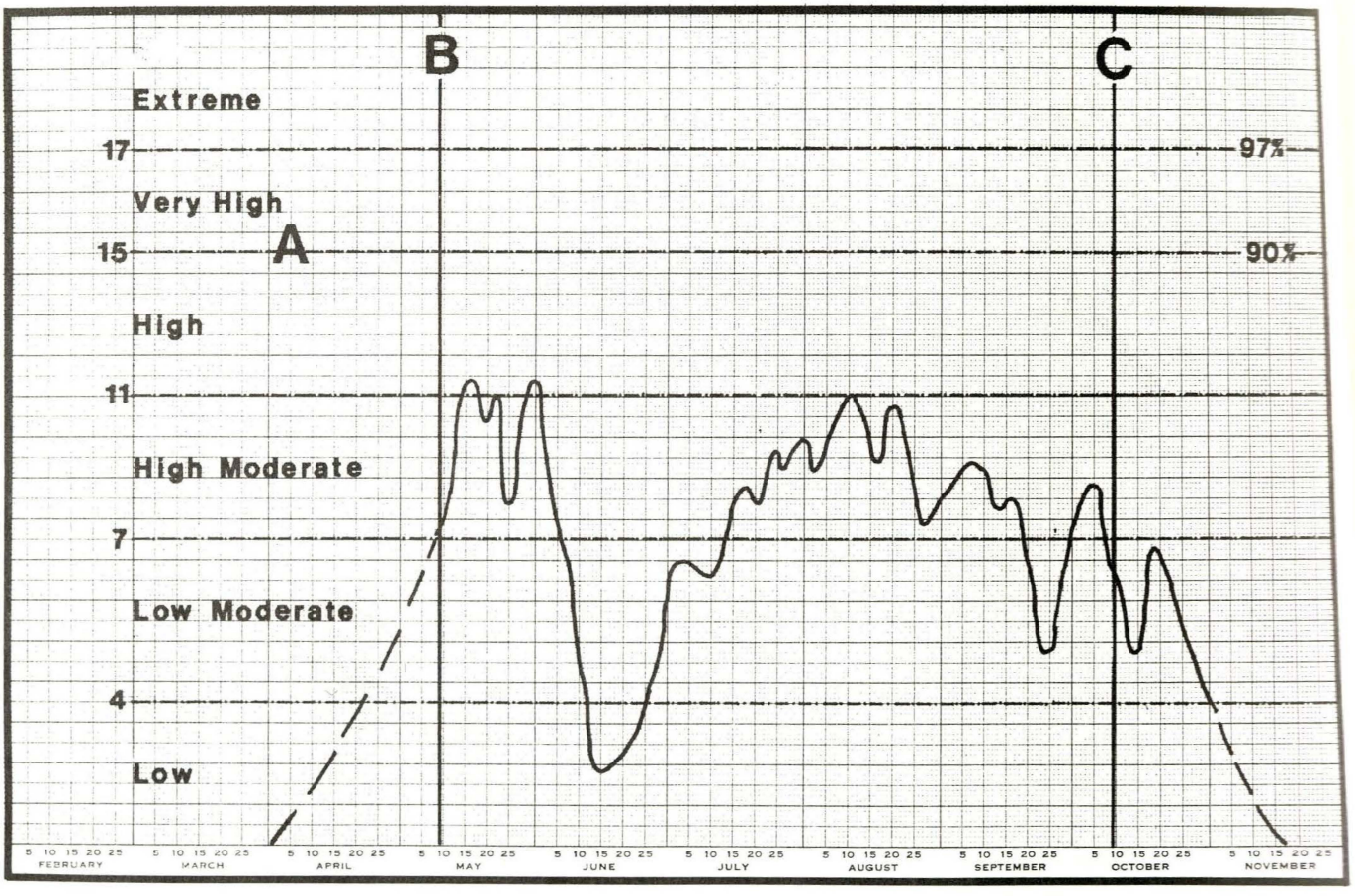


Figure 8.–*Fire manager's hand-drawn seasonal graph of the BI.*

If you asked for the computer printed graphs of the **seasonal tables**, you could draw the manning classes and the seasonal curve on them, but it would be difficult to overlay a plastic sheet on such a large graph.

Persistence Probability Table

Persistence measures how likely something is to remain the same. The fraction of the time that the weather will be the same tomorrow as it is today is tabulated in the SEASON's **persistence probability table** (fig. 9). The higher the persistence, the less likely the weather will change. SEASON produces monthly **persistence probability tables** for the chosen variable.

Information at the top of the table indicates the total number of years, the month for which data are being tabulated, and the specific years included. One page of output will be produced for each month of data. In our example, the burning index is divided into six manning classes (using table 1). These six classes make up both the row and column headings in each of the three parts of figure 9. Today's BI's are found in the rows **(A)** and tomorrow's BI's are found in the columns **(B)**. The ranges illustrated in the **persistence probability table** were computed by FIRDAT. However, you can select them by coding on lead card three (see Appendix Ic, item 9).

The **persistence probability table** reports the total number of pairs of days that were found **(C)**. (A pair occurs whenever there are weather observations on 2 consecutive days.) Out of a possible 186 pairs (31 days x 6 years), 180 pairs were found. The greatest number of pairs occurred when the BI was in the 5-8 class 1 day and continued in the same class through the next day 29 times **(D)**.

Figure 9 is divided into three parts. The top third tells how many times each pair of BI's (today's and tomorrow's) falls within each of the manning class ranges (both rows and columns). In our example, **E** shows that the BI was in the extreme range 2 days in a row (both today and tomorrow) two times in the 6 years under study.

1988 NFDRS VERSION FFY 3.0 PERSISTENCE PROBABILITY
KOOTENAI NF LIBBY MONTANA 240107
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2

--PERSISTENCE-- 6 YEARS OF DATA FOR AUG

YEARS OF DATA 1972, 73, 74, 75, 76, 77,

TOMORROWS BURNING INDEX (AUG) 180 PAIRS **C**

TODAYS BURNING **B**	0- 4	5- 8	9- 11	12- 15	16- 17	18- 26
A 0 - 4	18	13	2	0	0	0
5 - 8	8	29 **D**	8	0	0	0
9 - 11	7	1	17	17	0	0
12 - 15	2	2	12	18	6	4
16 - 17	0	0	2	4	2	1
18 - 26	0	0	0	4	1	2 **E**

0 - 4	54.55	39.39	6.06	.00	.00	.00
5 - 8	17.78	64.44	17.78	.00	.00	.00
9 - 11	16.67	2.38	40.48	40.48	.00	.00
12 - 15	4.55	4.55	27.27	40.91	13.64	9.09
16 - 17	.00	.00	22.22	44.44	22.22	11.11
18 - 26	.00	.00	.00	57.14 **F**	14.29	28.57

0 - 4	10.00	7.22	1.11	.00	.00	.00
5 - 8	4.44	16.11	4.44	.00	.00	.00
9 - 11	3.89	.56	9.44	9.44	.00	.00
12 - 15	1.11	1.11	6.67	10.00	3.33	2.22
16 - 17	.00	.00	1.11	2.22	1.11	.56
18 - 26	.00	.00	.00	2.22	.56	1.11 **G**

Figure 9.–*Persistence probability table.*

The middle third tells what percentage of the time a BI today was followed by each of the BI ranges tomorrow. The bottom row of the middle section **(F)** shows that if our BI is 18-26 today, then 57 percent (57.14) of the time tomorrow's BI will be in the 12-15 range. The chance that today will be followed by the next range (16-17) is 14 percent. Finally, the chance that the BI tomorrow will be in the same range as it is today is 29 percent. The fire manager could use this section of the table to predict the range of tomorrow's burning index after observing today's BI. The fire manager would want to pay particular attention to very high or extreme conditions. As the previous example showed, if the BI is in the extreme range today, there is a 29 percent chance that tomorrow's BI will also be in the extreme range. These historic data are used primarily to determine if firefighters should be ready to attack tomorrow's fires.

The bottom third of the figure indicates the percentage of the time that any particular combination of today's and tomorrow's values occurs. For example, the

occurrence of extreme days following one another **(G)** is only 1.11 percent of the time in August. This means that the fire organization should plan to have 2 of their worst days back-to-back about once every third August (1.11 percent of 31 days in August = 0.34 days or about once every third August).

Note: If you want to see your persistence probability, **don't** turn on the **single year graph** feature in SEASON.

BI Seasonal Severity

The seasonal severity routine uses the burning index to rank how severe the fire weather was each year. Seasonal severity 1) lists those days that have a BI exceeding the 90th percentile and 2) summarizes the data by months and year.

BI Seasonal Severity List

The **BI seasonal severity list** (fig. 10) ranks each year at a fire weather station in terms of the burning index. The ranking takes into account both how often and by how much each day's BI exceeded the 90th percentile BI level. The column headings **(A)** identify the dates that exceeded the 90th percentile BI, the BI value on these dates, the cumulative departures, and finally, the number of days in that year that the BI exceeded the 90th percentile. The program shows the upper boundary of the 90th percentile BI (90% = 15) **(B)**.

We see that the first day in 1972 to exceed the 90th percentile value was May 19. The difference (17-15 = 2) was entered in the cumulative departure column. The cumulative departure totals the daily departures (Daily departures = $BI_{today} - BI_{90\ percentile}$). The August 11 daily departure (16-15 = 1) was added to the previous two cumulative departure points to equal three cumulative departure points and so on.

Our example also shows the beginning of the 1973 fire season **(C)** where we note 8 days in a row exceeding the 90th percentile BI (from May 15 to May 22). Such periods would force a fire suppression group to respond day after day at its maximum strength.

```
1988 NFDRS    VERSION FFY 3.0                          BI SEASONAL SEVERITY LIST
KOOTENAI NF   LIBBY MONTANA          240107
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2


CUMULATIVE BI SEVERITY

A  DATE      BI      CUMULATIVE      NUMBER        B 90%=  15 (VALUE MAY BE CALCULATED OR SET.)
          VALUE     DEPARTURE      OF DAYS
   72 519    17          2             1
   72 811    16          3             2
   72 829    18          6             3
   72 830    19         10             4
   7210 3    16         11             5
   7210 5    16         12             6
   7210 7    16         13             7

   73 515 C  17          2             1
   73 516    25         12             2
   73 517    19         16             3
   73 518    19         20             4
   73 519    26         31             5
   73 520    17         33             6
   73 521    18         36             7
   73 522    16         37             8
   73 531    18         40             9
   73 6 1    16         41            10
   73 6 4    17         43            11
```

Figure 10.–*BI seasonal severity list.*

BI Seasonal Severity Summary Table

The data in the **BI seasonal severity list** are summarized in the **BI seasonal severity summary table** (fig. 11). The months **(A)** are listed horizontally above the summarized information. The cumulative departures and the number of days above the 90th percentile value for all the months are tabulated **(B)**. Both the total departures (113) and the number of days above the 90th percentile (38) are shown at **C**. The annual ratings for 1973 **(D)** show that the total departures were 3.340 times greater than the average. Similarly, the day count **(E)** shows that there were 2.923 more days above the 90th percentile than normally occur. The product of the BI and day columns **(F)** for 1973 is 9.763. The average annual departure and number of days are reported at **G**. Our example shows that in these 6 years, the average BI departure was 33.8 and the average number of days above the 90th percentile was 13.00. Because the station has a 123-day fire season, we expected about 11 percent of the days to exceed the 90th percentile level.

Remember that this method evaluates the weather of each year, not wildfire activity.

SEASON Lead Card Three

Appendix Ic describes the coding necessary for the SEASON routine. Code 3 in card column 1 (item 1) identifies a SEASON lead card. SEASON can plot the NFDRS components and indexes (item 3, list 1), the weather elements (item 3, list 2), or the living and dead fuel moistures (item 3, list 3). You choose the list you want by coding the number 1, 2, or 3 in card column 2. Then from that list select the variables that you want tabulated or graphed. You **must** select one list and at least one variable or SEASON will not function. Leave the card column blank for every variable you don't want tabulated or graphed.

You may select **seasonal graphs**, **tables**, or both by coding a "T" or "F" in columns 11 and 12 (items 4 and 5). The averaging period for graphs and tables (columns 13-14) must be an odd number between 01 and 31 (item 6). If you choose 1 day, a jagged graph will result. Increasing the averaging period will "smooth" the graph (see fig. 8 for an example). Use 3, 5, or 7 days as your running mean for a "smoothed" graph.

If you want a graph of individual years, code "T" in column 15 (item 7). Because this feature has limited value, you will usually code "F." Note: The **single year graph** feature automatically turns off the **BI seasonal severity list** and **summary table** and **persistence probability tables**. It may also create excessive paper and expense (see Appendix II, item 7).

If you don't want any **persistence probability tables**, enter a 0 in column 16, item 8. However, if you do want a **persistence probability table**, you must choose one of the NFDRS indexes or components from item 3 that you coded in columns 3-10. Code the number of the variable in column 16. (For example, in fig. 9 we coded list number 1 in card column 2 and coded 6 in column 8, so we could again code 6—the burning index—in card column 16.)

You will usually run FIRDAT first, analyze the data, and then run SEASON. (SEASON will use weather data from the **passing file**.) As part of this analysis, you will find the 90th and 97th percentile values of your variable on your **frequency distributions table** (fig. 4, **I**). Item 9 tells you to code your upper boundary levels in columns 17-34 on lead card three. In our example (table 1), we would code 004 in columns 17-19, 007 in columns 20-22, and so on.

You can force FIRDAT to compute the upper boundaries of the variable chosen in item 8 by running FIRDAT and SEASON at the same time and placing the number of the variable from the list in item 3 into column 62 on lead card two. The computer will then automatically calculate the upper and lower boundaries and you need not fill in columns 17-34 in item 9 on lead card three.

You may obtain the **BI seasonal severity list** and **summary table** by placing a "T" in column 35 (item 10). If this SEASON run immediately follows a FIRDAT run, SEASON will remember the 90th percentile value of the BI, so leave item 11 blank. However, if you run SEASON independently with the **passing file**, then you must specify the 90th percentile BI in columns 36-38.

The **BI seasonal severity summary table** (fig. 11) can be produced in two ways. If this is a run with FIRDAT, you should leave columns 39-48 blank. The routine will calculate the average departure points and number of days and print them (fig. 11, **G**). Later, you may wish to compare the BI seasonal severity with different average values for the departures and number of days. You can instruct the routine to use these values by placing them in card columns 39-48. In our example, the columns on lead card three were left blank and the computer determined the average values.

1988 NFDRS VERSION FFY 3.0 BI SEASONAL SEVERITY SUMMARY 27 OCT. 89 PAGE 63
KOOTENAI NF LIBBY MONTANA 240107 ELEVATION- 2070 LATITUDE-49
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2 FIRE SEASON- 5/ 9 TO 9/ 9

THESE SEVERITY RATINGS ARE BASED ON AVERAGE DATA, NOT USER SUPPLIED. BI(90%)= 15

A

YEAR	JAN DEP-DY	FEB DEP-DY	MARCH DEP-DY	APRIL DEP-DY	MAY DEP-DY	JUNE DEP-DY	JULY DEP-DY	AUG DEP-DY	SEPT DEP-DY	OCT DEP-DY	NOV DEP-DY	DEC DEP-DY	TOTALS DEP-DY	RATINGS BI	DAY	BI X DAY
1972	0- 0	0- 0	0- 0	0- 0	2- 1	2- 1	2- 1	10- 4	10- 4	13- 7	13- 7	13- 7	13- 7	.384	.538	.207
1973	0- 0	0- 0	0- 0	0- 0	40- 9	43-11	82-25	112-37	113-38	113-38	113-38	113-38	113- 38	3.340	2.923	9.763
1974	0- 0	0- 0	0- 0	0- 0	12- 5	12- 5	12- 5	13- 6	22- 7	22- 7	22- 7	22- 7	22- 7	.650	.538	.350
1975	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0	.000	.000	.000
1976	0- 0	0- 0	0- 0	0- 0	9- 6	9- 6	11- 7	11- 7	11- 7	11- 7	11- 7	11- 7	11- 7	.325	.538	.175
1977	0- 0	0- 0	0- 0	4- 3	5- 4	20- 9	44-19	44-19	44-19	44-19	44-19	44-19	44- 19	1.300	1.462	1.901
TOTAL													203- 78			
AVRGE	0- 0	0- 0	0- 0	0- 0	10- 3	3- 1	10- 4	6- 2	1- 0	0- 0	0- 0	0- 0	33.8- 13.00			

B C D E F

YEARS= 6

G

Figure 11.–*BI seasonal severity summary table.*

FIRINF ROUTINE

Although SEASON analyzes only one NFDRS variable at a time, FIRINF can provide information on combinations of two variables. Many agencies combine two variables to determine their adjective or manning classes. For example, fire managers often combine the IC (a measure of fire occurrence) with the BI (a measure of fire intensity) to determine these classes. They can use these FIRINF tables for planning detection flights, wildfire prevention activities, industrial closures, and specific action guides. Both SEASON and FIRINF get their data from the **passing file** produced by FIRDAT. The FIRINF routine uses only the first 3,600 days of historical weather data, so you may wish to decide which 10 years are the most important to you and code them on a new lead card one (see Appendix Ia, item 9).

Adjective Class Matrix

The **adjective class matrix** (fig. 12) is one of the most frequently used fire management tools. It combines the IC with the agency's manning class index or component to help provide the public with fire-danger levels.

Figure 12 demonstrates how the BI was used to provide the manning classes. The values FIRE-FAMILY computed for you or that you entered on lead card four (Appendix Id) are displayed at **A** in figure 12. Bold letter **B** shows the first pair of "x values" (0-20), which defines the boundaries of the first column. Each subsequent pair defines another column. The **adjective class matrix** always includes the same five ranges of the ignition component. The first "y value" pair (0-4) defines the first row of the BI. The other pairs define the remaining rows.

In figure 12, the row with a BI of 12-13 shows two "M's" (moderate), two "H's" (high), and a "V" (very high) in the columns from left to right. Other symbols found in the matrix are "L" (low) and "E" (extreme). A summary of the number of days in the data base and the number of days actually used is shown at the bottom of the printout.

This table provides the fire manager with a quick overview of how the IC and BI together affect the adjective class levels. For clarity we have outlined the area of the table containing the very high and extreme days **(C)**.

Instead of the **adjective class matrix**, you can obtain the **precautions class matrix**, a similar table often used to determine forest closures. The **precautions class matrix** uses a different range of column headings for the IC and allows the user to choose the variable (often the energy release component or the BI) to determine the manning classes.

FIRINF also provides you with an opportunity to form your own matrix to give you more information than that offered in either the **adjective** or **precautions class matrices**. You may combine any two of the eight variables listed on lead card four to produce the user-defined matrix. You may have to use a second or third lead card four for this purpose. Place "F's" in columns 2 and 3. Code the first variable number in column 4 and the second in column 35 and specify up to 10 upper boundaries of each index or component in the provided card columns (see Appendix Id).

Adjective Class Calendar

The **adjective class calendar** (fig. 13) indicates the adjective levels assigned by the **adjective class matrix** to each day for which you have historical weather data. **Precautions class** or **user-defined matrices** also produce a similar calendar.

FIRINF prints out the date (year—72, month—08, day—09) **(A)**. A dot (.) is printed above the first digit of the year. (Notice that the dates are printed below one another in groups of seven, indenting one column each time.) The adjective class letter (M—moderate) for the first date is printed in the row labeled M. (A row is provided for each class—L, M, H, V, E.) You can easily see the changes in adjective levels on a daily basis.

Find August 30, 1972, in the calendar **(B)**. Using a straight edge, draw a line up from the 7 (the first digit of the year) beyond its dot through the letter H **(C)**. Use this method to find the adjective rating for any day in your data base. In general, you will look at your calendar for repeated very high (V) or extreme (E) days. The **adjective class calendar** graphically illustrates persistence of adjective levels. In the **precautions class** and **user-defined matrices**, the letters A, B, C, D, E, and F are used to show class categories. "A" is the lowest level of fire danger.

Probability Analysis

Once you have asked for the **adjective class matrix**, you will get an **adjective class calendar** as well as monthly and annual **probability analysis tables**. These **probability analysis tables** will provide you with some of the detailed information necessary to

plan your fire management activities. The tables will show how often you can expect values of your adjective class to occur. In figure 14, the table rows indicate the ranges of numerical values for the BI and the columns indicate the ranges of the ignition component.

The **probability analysis table** is divided into three parts. The top third **(A)** tells how often combinations of the BI and the IC occurred. Our example shows that in the 1,111 days for which we have data, there were 11 days when the BI was 18-21 and the IC was in the range of 0-20. On 8 other days, when the BI was 18-21 the IC was in the range of 21-45.

The middle of the table **(B)** tells the percent of the time that the ignition component is in each column, given that the BI is in a particular row. For example, in the BI row labeled 22-26 we see that 25 percent of the time the ignition component was in the range 0-20 and 75 percent of the time the ignition component was in the 21-45 range.

1988 NFDRS VERSION FFY 3.0 SUMMARY OF FIRINF VARIABLES
KOOTENAI NF LIBBY MONTANA 240107
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2

A

X VALUES		Y VALUES	
0	20	0	4
21	45	5	8
46	65	9	9
66	80	10	11
81	100	12	13
101	0	14	15
0	0	16	16
0	0	17	17
0	0	18	21
0	0	22	26

THE ADJECTIVE CLASS MATRIX

BURNING INDEX	IGNITION COMPONENT											
B	0- 20	21- 45	46- 65	66- 80	81-100	101- 0	0- 0	0- 0	0- 0	0- 0	0- 0	0- 0
0- 4	L	L	L	M	M							
5- 8	L	M	M	M	H							
9- 9	M	M	H	H	V							
10- 11	M	M	H	H	V							
12- 13	M	M	H	H	V							
14- 15	M	M	H	H	V							
16- 16	M	H	V	V	E							
17- 17	M	H	V	V	E							
18- 21	H	V	V	E	E							
22- 26	H	V	V	E	E							

C

1111 DAYS OF RECORD ACCEPTED FROM 1111 DAYS READ FROM THE PASSING FILE.

Figure 12.–*Adjective class matrix.*

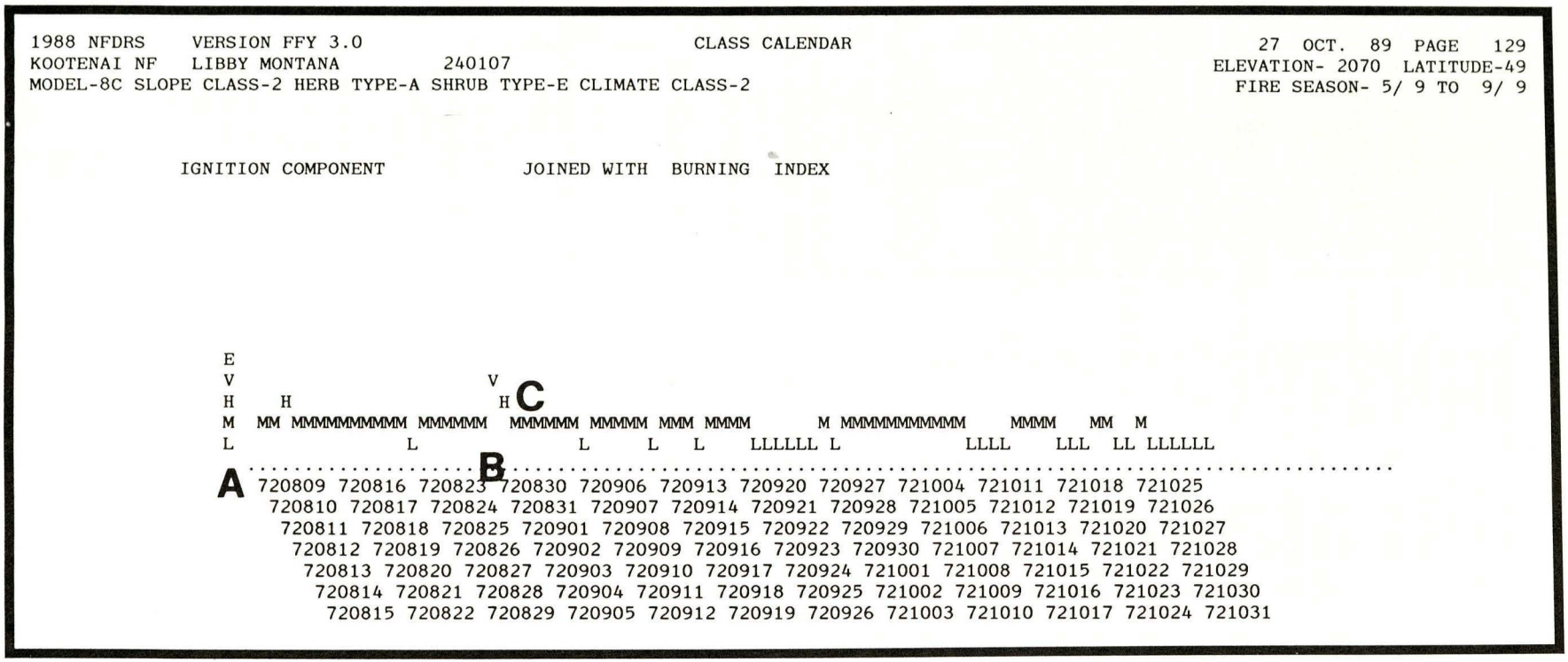


Figure 13.–*Adjective class calendar.*

1988 NFDRS VERSION FFY 3.0 PROBABILITY ANALYSIS 27 OCT. 89 PAGE 136
KOOTENAI NF LIBBY MONTANA 240107 ELEVATION- 2070 LATITUDE-49
MODEL-8C SLOPE CLASS-2 HERB TYPE-A SHRUB TYPE-E CLIMATE CLASS-2 FIRE SEASON- 5/ 9 TO 9/ 9

IGNITION COMPONENT VERSUS BURNING INDEX

	BURNING INDEX	IGNITION COMPONENT 0- 20	21- 45	46- 65	66- 80	81-100	1111 DAYS IN TOT. 101- 0	0- 0	0- 0	0- 0	0- 0
A	0- 4	290	0	0	0	0	0	0	0	0	0
	5- 8	294	0	0	0	0	0	0	0	0	0
	9- 9	89	0	0	0	0	0	0	0	0	0
	10- 11	152	0	0	0	0	0	0	0	0	0
	12- 13	133	0	0	0	0	0	0	0	0	0
	14- 15	75	0	0	0	0	0	0	0	0	0
	16- 16	33	1	0	0	0	0	0	0	0	0
	17- 17	13	4	0	0	0	0	0	0	0	0
	18- 21	11	8	0	0	0	0	0	0	0	0
	22- 26	2	6	0	0	0	0	0	0	0	0
B	0- 4	100.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	5- 8	100.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	9- 9	100.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	10- 11	100.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	12- 13	100.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	14- 15	100.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	16- 16	97.06	2.94	.00	.00	.00	.00	.00	.00	.00	.00
	17- 17	76.47	23.53	.00	.00	.00	.00	.00	.00	.00	.00
	18- 21	57.89	42.11	.00	.00	.00	.00	.00	.00	.00	.00
	22- 26	25.00	75.00	.00	.00	.00	.00	.00	.00	.00	.00
C	0- 4	26.10	.00	.00	.00	.00	.00	.00	.00	.00	.00
	5- 8	26.46	.00	.00	.00	.00	.00	.00	.00	.00	.00
	9- 9	8.01	.00	.00	.00	.00	.00	.00	.00	.00	.00
	10- 11	13.68	.00	.00	.00	.00	.00	.00	.00	.00	.00
	12- 13	11.97	.00	.00	.00	.00	.00	.00	.00	.00	.00
	14- 15	6.75	.00	.00	.00	.00	.00	.00	.00	.00	.00
	16- 16	2.97	.09	.00	.00	.00	.00	.00	.00	.00	.00
	17- 17	1.17	.36	.00	.00	.00	.00	.00	.00	.00	.00
	18- 21	.99	.72	.00	.00	.00	.00	.00	.00	.00	.00
	22- 26	.18	.54	.00	.00	.00	.00	.00	.00	.00	.00

D

Figure 14.—*Probability analysis table.*

The lower third of the table **(C)** tells the percentage of all the days on which each combination of the BI and IC occurred. Thus in our example, on 0.99 percent of the 1,111 days, the BI was in the range of 18-21 and the ignition component had a value between 0-20. Similarly, on 0.72 percent of the days, the BI was between 18 and 21, and the ignition component ranged from 21 to 45.

Probability analysis tables are helpful to fire managers using historical weather data for planning and budgeting. On figure 12 we outlined the area of the table containing the very high and extreme days. We have used the same rows and columns to outline the identical portion of figure 14 **(D)**. Adding all of the percentages within the outlined area, we find that a total of 1.26 percent of the 1,111 days were in the very high or extreme range in the past. Therefore, the fire manager would budget for an average of 5 very high and/or extreme days per year.

In addition to the monthly **probability analysis tables**, you will receive a yearly **probability analysis table** showing the same kind of information.

If you ask for a **precautions class** or **user-defined matrix**, you will receive **probability analysis tables** for them also. You can analyze them in the same way that you analyzed the **probability analysis table** for adjective classes.

FIRINF Lead Card Four

An example of the FIRINF lead card is shown at the bottom of the FIREFAMILY header page (fig. 1, **D**). A "4" printed in card column 1 (Appendix Id, item 1) identifies each FIRINF card. Item 2, Appendix Id, allows the user to select or reject the **adjective class matrix** by coding a "T" (true) or an "F" (false) in card column 2. If you run FIRDAT and FIRINF at the same time and you code a "6" in card column 62 of lead card two, FIRDAT will then compute the upper boundaries of your BI. Because the computer will then automatically provide the ranges of the BI, you need not fill in the rest of lead card four. When requesting the **adjective class matrix**, you must code an "F" in column 3 of lead card four. You can leave card column 4 blank because the IC is always used in the **adjective class matrix**. Both columns 2 and 3 may be coded false.

Usually you will be running FIRINF with a previously created **passing file**. The program will compute the upper boundaries of the IC for you, so leave columns 4-34 blank. But you must code the number of the variable you want combined with the IC into card column 35. Use our table 1 or Appendix E of the AFFIRMS manual (Helfman *et al.* 1987) to find a method to determine up to 10 upper boundaries of your chosen variable. Enter these boundaries in card columns 36-65.

A similar table to the **adjective class matrix**—the **precautions class matrix**—can be selected by coding an "F" in card column 2 and a "T" in card column 3. Just as for the **adjective class matrix**, if you are running FIRINF with FIRDAT and code number 3 (ERC) in card column 62 of lead card two, FIRDAT will provide the row ranges, so you can leave the rest of lead card four blank. If you have run FIRDAT previously, however, follow the coding routine suggested for the **adjective class matrix**, but use the ERC, the BI, or another variable for the rows.

Instead of selecting either the **adjective** or **precautions class matrices**, you can construct any other table by combining two variables from the list in Appendix Id, item 4. You might wish to construct your own table because your agency does not use the same method for determining manning classes that has been provided by FIRINF, or you may wish to choose indexes or components other than those provided by FIRINF. Code as follows: put the code number of your chosen column variable in card column 4 and the row variable in column 35. Constructing tables this way requires you to enter up to 10 of the upper boundaries for the ranges of the chosen variables. These numbers will appear in the columns and rows on the table you are constructing. Enter upper boundaries for the first variable in card columns 5-34, leaving any unused columns blank. Choose up to 10 upper boundaries for the second variable and code these numbers in columns 36-65 (item 7).

CONCLUSION

We have shown how your historical weather data can be combined with the NFDRS to produce a variety of useful planning tools. The **frequency distributions tables** indicate the highest fire-danger levels of each index or component. The SEASON printouts show when to expect periods of sustained high fire danger. Indexes and components are combined in the **adjective** and **precautions class matrices** to provide both the public and private sectors with estimates of potential fire danger.

Now that you have seen what FIREFAMILY can do for you, your next step is to determine what your needs are and submit the appropriate lead cards to your

computer specialist. (You can photocopy the lead cards in Appendix I to make coding simpler.) The specialist will then combine your lead cards with the Fort Collins job-control cards shown in Appendix III.

ACKNOWLEDGMENTS

FIREFAMILY began as a collection of separate programs written by several people. The authors gratefully acknowledge the work of David Rainey, Robert J. Straub, and the late R. William Furman for their early contributions to FIREFAMILY. We also thank Roger L. Bradshaw for his patience and help in refining the program. Finally, we thank Mike Burbank for his assistance with the camera-ready figures.

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APPENDIX I.–LEAD CARD FORMATS

Two kinds of computer instructions are required to operate FIREFAMILY—program lead cards and job-control cards. Program lead cards are discussed thoroughly in this publication. Below we summarize general information about the program lead cards and suggest general rules for submitting the cards to the computer. Appendix II illustrates the number of pages likely to be produced. Appendix III shows the job-control cards needed to execute FIREFAMILY at Fort Collins and the format of the **passing file**. We have included this information in the Appendices for easy reference by your computer specialist.

There are four types of program lead cards: lead cards one and two control FIRDAT, lead card three controls SEASON, and four controls FIRINF. The identification number, always coded in column 1 of each card, determines how the program interprets the contents of that card. The cards must be properly formatted and submitted to the computer in the correct order. General rules are:

1. The lead cards must be entered from low card number to high for the same weather station.
2. More than one station may be included in the same run. (Submit a card one for each station.)
3. Order the lead card "ones" from lowest station number to highest.
4. Lead cards three and four do not have to be present in a run.
5. The first card in an entire group must be a card one.
6. The second card in an entire group must be a card two.
7. Once a card two, three, or four is entered, its instructions will remain in effect until altered by another card of the same type.
8. Cards three and four can exist in multiples of three cards each for the same station.

Ia.–FIRDAT Control–Lead Card One

ITEM	DESCRIPTION	CARD COLUMN(S)
1	Card Number	(1) _1_
2	Administrative owner's name	(2-13) _____
3	Station name	(14-33) _____
4	Station number	(34-39) _ _ _ _ _ _
5	Station elevation in feet (right justify)	(40-44) _ _ _ _ _
6	Station latitude, nearest degree	(45-46) _ _
7	NFDRS model-slope-herb-shrub-climate class combination (lead card two permits four additional combinations):	
	Model: 7 or 8 and A through U but not M	(47-48) _ _
	Slope: 1 through 5	(49) _
	Herbaceous: A or P only, annual or perennial	(50) _
	Shrub: D or E only, deciduous or evergreen	(51) _
	Climate Class: 1 through 4	(52) _
8	1 hr = 10 hr: Code true (T) or false (F) only.	(53) _
9	Range of years: First year	(54-55) _ _
	Last year	(56-57) _ _
	(Enter 00 and 99 to get all available data.)	
10	Fire season: Beginning month	(58-59) _ _
	Beginning day	(60-61) _ _
	Ending month	(62-63) _ _
	Ending day	(64-65) _ _
	(Enter 01 01 and 12 31 to include the entire year. Item 9 on lead card two allows you to skip a period of few fires.)	
11	If you want **frequency distributions tables** and **graphs** for particular indexes, components, and fuel moistures, code "T." Code "F" for those you don't want.	
	Variable:	
	Ignition component (IC)	(66) _
	Spread component (SC)	(67) _
	Energy release component (ERC)	(68) _
	Human-caused fire occurrence index (HCOI)	(69) _
	Lightning-caused fire occurrence index (LOI)	(70) _
	Burning index (BI)	(71) _
	Fire load index (FLI)	(72) _
	Keetch-Byram Drought Index (KDI)	(73) _
	Fuel moistures (FM) (You will get all four: the 1-hr, 10-hr, 100-hr, and 1,000-hr.)	(74) _
12	"T" produces a **daily list** of the weather, indexes, and components. This item is reset to "F" after the first model-slope-herb-shrub-climate combination has been processed. If you choose more than one combination on lead card two (item 7), and you want the **daily list** for each combination, code "A" (for ALL). An "F" will suppress all **daily lists**.	(75) _
13	"T" indicates you have a FIRDAT-created **passing file**; you will go directly to SEASON and/or FIRINF.	(76) _
14	"T" will list only the observed weather elements; no indexes or components will be printed.	(77) _
15	"T" causes FIRDAT to create a **passing file** for use with SEASON and/or FIRINF.	(78) _

Ib.–FIRDAT Control–Lead Card Two

ITEM	DESCRIPTION	CARD COLUMN(S
1	Card number	(1) _2_
2	Lightning risk scaling (LRS) factor. For the first run, enter 01.00. On later runs, adjust your LRS as indicated in Deeming *et al.*, Appendix D (1977).	(2-6) _____
3	Human-caused risk scaling factors. Columns 7-9 contain the average weekday risk and columns 10-12 contain the average weekend risk	(7-9) _____ (10-12) _____
4a	Month and day when green-up begins	(13-16) _____
4b	Month and day of the first killing frost	(17-20) _____
5	Average annual precipitation (in inches)	(21-24) _____
6	Beginning Keetch-Byram Drought Index	(25-27) _____
7	Beginning 1,000 hour timelag fuel moisture. Enter a station specific value if available. Otherwise, enter one of the following values (to the nearest whole percent), depending on which climate class you designated on lead card 1, column 52:	

Climate Class	Beginning 1,000 Hour
1	15
2	20
3	25
4	30

(28-29) _____

8	Up to four more model-slope-herb-shrub-climate combinations may be entered (see Appendix Ia, item 7).	(30-35) _____ (36-41) _____ (42-47) _____ (48-53) _____
9	If your station has a split fire season, you may enter the low risk period here: Beginning month and day Ending month and day	 (54-57) _____ (58-61) _____
10	You may select one variable from the following list and use its code number to have SEASON and FIRINF construct a variety of tables. (Leave blank if you are not using SEASON and/or FIRINF on this run.)	

Code	Variable
1	IC
2	SC
3	ERC
4	HCOI
5	LOI
6	BI
7	FLI
8	KDI

(62) _____

11	If you leave columns 63-66 blank, this program will print the 90th and 97th percentile levels of the index or component chosen in card column 62. Because your agency's planning methods may vary from those used by the USDA Forest Service, you may choose, for example, the 80th and 95th percentile levels. If so, code 8095.	(63-66) _____

Ic.–SEASON Control–Lead Card Three

ITEM	DESCRIPTION	CARD COLUMN(S)
1	Card number	(1) _3_
2	SEASON will graph and/or tabulate variables from one of these lists: 1 = NFDRS, 2 = Weather Elements, 3 = Fuel Moistures. Code your choice of list here.	(2) ___
3	From the item 2 list, select and code the number of any or all of the variables. Leave the column blank if you don't want to see a variable tabulated or graphed.	

Code	List 1	List 2	List 3	
	NFDRS	**Weather Elements**	**FM**	
1	IC	Temp	1-hr	(3) ___
2	SC	RH	10-hr	(4) ___
3	ERC	Wind	100-hr	(5) ___
4	HCOI	Prec. dur.	1,000-hr	(6) ___
5	LOI	Prec. amt.	Woody	(7) ___
6	BI	LAL	Herb	(8) ___
7	FLI	Herb greenness factor		(9) ___
8	KDI	Woody greenness factor		(10) ___

4	**Seasonal graphs**? "T" = yes, "F" = no.	(11) ___
5	**Seasonal tables**? "T" = yes, "F" = no.	(12) ___
6	Averaging periods for tables and graphs; code with an odd number, 01-31 only.	(13-14) ___ ___
7	Graph individual years? "T" = yes, "F" = no. This feature may produce many pages of printout. It also turns off the **persistence probability tables** and the **BI seasonal severity list** and **summary table**.	(15) ___
8	Persistence probability variable: use one variable code from the list you chose in item 3. Code 0 if you do not want a **persistence probability table**.	(16) ___
9	Select up to six upper boundaries for your persistence probability variable. (FIRDAT will do this if you place a code in column 62 of lead card two.) Enter boundaries in ascending order, right justified.	(17-19) ___ ___ ___ (20-22) ___ ___ ___ (23-25) ___ ___ ___ (26-28) ___ ___ ___ (29-31) ___ ___ ___ (32-34) ___ ___ ___
10	**BI seasonal severity list** and **summary table**? "T" = yes, "F" = no.	(35) ___
11	Enter the 90th percentile BI value. Leave blank if you are combining SEASON with a FIRDAT run (round off BI value, no decimal point, right justify).	(36-38) ___ ___ ___
12	To compare BI seasonal severity with different averages for the departures and number of days, enter average yearly departure, with decimal point, in columns 39-43, and enter the average yearly number of days over the percentile in columns 44-48. (Leave columns 39-48 blank unless you want this feature.)	(39-43) ___ ___ ___ ___ ___ (44-48) ___ ___ ___ ___ ___

Note: You may have up to three SEASON cards in each run. To turn SEASON off, leave the card blank except for the code "3" in column 1.

Id.–FIRINF Control–Lead Card Four

ITEM	DESCRIPTION	CARD COLUMN(S)
1	Card number	(1) _4_
2	**Adjective class matrix**? "T" = yes, "F" = no. If "T" is coded in column 2, "F" must be coded in column 3. (Both columns 2 and 3 may be false.)	(2) ___
3	**Precautions class matrix**? (See above.)	(3) ___
4	Choose the variable to be used for the table columns from the following list:	

Code	Variable
1	IC
2	SC
3	ERC
4	HCOI
5	LOI
6	BI
7	FLI
8	KDI

		(4) ___
5	Code up to 10 upper boundary values for the table columns.	(5-7) ___
		(8-10) ___
		(11-13) ___
		(14-16) ___
		(17-19) ___
		(20-22) ___
		(23-25) ___
		(26-28) ___
		(29-31) ___
		(32-34) ___
6	Choose a code number for another variable from the list in item 4 for the table rows.	(35) ___
7	Code up to 10 upper boundary values for the rows.	(36-38) ___
		(39-41) ___
		(42-44) ___
		(45-47) ___
		(48-50) ___
		(51-53) ___
		(54-56) ___
		(57-59) ___
		(60-62) ___
		(63-65) ___

Note: This card may be repeated up to three times. Turn FIRINF off by coding card columns 2 and 3 false and leaving the rest of the card blank.

APPENDIX II.–OUTPUT PAGE ESTIMATOR

FEATURES	PAGES	TOTAL PAGES*
1) **Header page**	1 page per combination	5
2) **Daily list** (if T)	Total days/50	60
(if A)	Total days x combinations/50	300
3) **Annual summary**	Years x combinations	100
4) **Cumulative frequency**	2 pages x combinations x frequencies selected	110
5) **SEASON graph**	4 pages x combinations x variables selected x SEASON cards	420
6) **SEASON tables**	3 pages x combinations x variables selected x SEASON cards	315
7) **Single year graph**	Multiply item 5 or item 6 x years	8,400(5) 6,300(6)
8) **Persistence probability**	6 pages x combinations x SEASON cards	90
9) **BI seasonal severity**	5 pages x combinations	45
10) **FIRINF**	22 pages x combinations x FIRINF cards	330

*With five combinations, 20 years (3,000 days), and everything turned on (three SEASON and three FIRINF cards), the output would be 15,545 pages.

Note: When the **single year graph** feature is on, FIREFAMILY produces a great deal of paper even though it turns off everything else in SEASON.

APPENDIX III.–JOB RUNSTREAMS AND PASSING FILE FORMAT

The Fort Collins Computer Center, home of FIREFAMILY, is equipped with a UNIVAC 1100 series computer and the EXEC 9 operating system. Changes in FCCC equipment or systems may make the following examples and job instructions obsolete.

The first part of Appendix III will help your computer specialist set up the job-control language needed to execute FIREFAMILY at FCCC.

We have included two typical runstreams. The first shows how to access the National Fire Weather Data Library (see Furman and Brink 1975) to obtain historical weather records, execute the FIREFAMILY program, and catalog the **passing file**. Our second example shows how to use a previously created **passing file** as input to the FIREFAMILY routines SEASON and FIRINF.

Appendix IIIc shows the format of the **passing file**.

IIIa.–Running FIREFAMILY Using Historical Weather Data

@Run,*P/B YOUR ID,ACCOUNT NUMBER,QUALIFIER,TIME,PAGES*
@ASG,A FIREDATALIB★PROGRAMS.
@ASG,A FIREDATALIB★*21-24. (Get the fire weather tape.)*
@ASG,UP *YOUR-DATA. (Unconditionally catalog the weather holding file.)*
@USE 2.,FIREDATALIB★*21-24.*
@USE 15., *YOUR-DATA.*
@XQT FIREDATALIB★PROGRAMS.GETDATA2 *(Get the required weather data.)*
24010700 24010799
@EOF
@ASG,UP PASS. *(Unconditionally catalog the passing file.)*
@USE 7.,*YOUR-DATA. (Use the data just obtained from the NFWDL.)*
@USE 9.,PASS.
@HDG,N X.M,66,0,0 *(Turn off normal page control.)*
@XQT NFDR88★FIREFAMILY.FIRDAT1 *(Execute the program.)*
1KOOTENAI NF LIBBY MONTANA 240107 2070498C2AE2F009905090909TTTTTTTTTTFFT
2 1.00 12 120601091020.300020 69097
3112345678TT01F6
4TF
@SAVE *QUALIFIER* ★PASS.,*900301 (Save the passing file until March 1, 1990.)*
MY FIRDAT PASSING FILE'S NAME
(The qualifier must be explicitly specified and the above file description line must be included.)
@FIN

IIIb.–Running FIREFAMILY Using a Previously Created Passing File

@RUN,*P/B YOUR ID,ACCOUNT NUMBER,QUALIFIER,TIME,PAGES*
@ASG,A *QUALIFIER* ★PASS. *(Assign previously created passing file to this run.)*
@USE 9.,*QUALIFIER* ★PASS.
@HDG,N X.M,66,0,0 *(Turn off normal page control.)*
@XQT NFDR88★FIREFAMILY.FIRDAT1 *(Execute the program.)*
1KOOTENAI NF LIBBY MONTANA 240107 2070498C2AE2F0099050909FFFFFFFFFFTFF
2 1.00 12 120501091020.300020 69097
3112345678TT01F3
4FT
@FIN

(*Parenthetical expressions explain each job-control card.*)
UPPER CASE ITALICS indicate where coding will differ from run to run.

IIIc.–FIREFAMILY Passing File Format

The **passing file**, a product of FIRDAT, is used to transfer weather, fuel moistures, and NFDRS components and indexes from FIRDAT to SEASON and/or FIRINF. If retained after the FIRDAT run, this computer readable file can be reused as input to SEASON and/or FIRINF. It may also be used as input to future analysis programs.

The **passing file** contains three kinds of records: a flag indicating a change of station or change of station parameters, a header reporting the station parameters, and the daily data values.

Item	Columns	Type*
RECORD ONE, Flag:		
Flag: 999999999999	1-12	N
RECORD TWO, Header:		
Administrative owner	1-12	A-N
Station name	13-32	A-N
Station number	33-38	N
Elevation	39-43	N
Latitude	44-45	N
Fuel model	46	A
Slope class	47	N
Herbaceous type	48	A
Climate class	49	N
Julian green-up date	50-52	N
Run date	53-64	A-N
Julian first freeze	65-67	N
Beginning and ending years	68-71	N
RECORD THREE, Daily Data:		
Station number	1-6	N
Date	7-12	N (year-month-day)
Julian date	13-15	N
Processing option	16	N
State of weather	17	N
Temperature	18-20	N
Relative humidity	21-23	N
Wind direction	24	N (8 point compass
Wind speed	25-27	N
Max temperature	28-30	N
Min temperature	31-33	N
Max relative humidity	34-36	N
Min relative humidity	37-39	N
Precipitation duration	40-41	N (hours)
Precipitation amount	42-45	N (10.94 written as 1094)
Lightning activity level	46	N
Human-caused risk	47-49	N
1-hour fuel moisture	50-52	N (14.5 written as 145)
10-hour fuel moisture	53-55	N (14.5 written as 145)
100-hour fuel moisture	56-58	N (14.5 written as 145)
1,000-hour fuel moisture	59-61	N (14.5 written as 145)
Woody moisture	62-64	N
Herbaceous moisture	65-67	N
Blank	68-69	N
Ignition component	70-72	N
Spread component	73-75	N
Energy release component	76-78	N
Human-caused fire occurrence index	79-81	N
Lightning-caused fire occurrence index	82-84	N
Burning index	85-87	N
Fire load index	88-90	N
Keetch-Byram index	91-93	N
Herb greenness factor	94-96	N
Woody greenness factor	97-99	N

* *A-N = Alpha-numeric data fields contain alphabetic (A) and/or numeric (N) characters.*

APPENDIX IV.–ANALYZING NFDRS WEATHER DATA USING 1978 OR 1988 FUEL MODELS

The FIRDAT routine of FIREFAMILY was revised after the NFDRS fuel models were revised in 1988. Fire managers can now use FIREFAMILY 1988 to analyze historical weather data collected both before and after 1988. The following describes how FIRDAT addresses the four combinations of 1978 and 1988 fuel model sets and styles of weather data.

Running a 1988 fuel model set with the 1978 style of weather data:

1. Allows the fire manager the option to set the fine fuel moisture always equal to the 10-hour fuel moisture. Even if the fire manager does not select this option, FIRDAT will make the fine fuel moisture equal to the 10-hour fuel moisture on the day of and the day after more than 0.1 inch of precipitation.
2. Adjusts the 1988 wind reduction factor between minimum and maximum values by comparing today's live woody vegetation load to the maximum live woody vegetation load for the model. The wind reduction factor will vary only for the deciduous models. It is not possible to adjust the wind reduction factor as a function of the woody greenness factor because the latter did not exist in the 1978 style of weather data.
3. Multiplies the wind reduction factor by 0.3 on the day of and the day after at least 0.1 inch of precipitation.
4. Does not alter the calculation procedures of the 100-hour, 1,000-hour, live woody, and live herbaceous moistures. They are the same as when running a 1978 fuel model set with 1978 style weather data.
5. Modifies the fine fuel load through curing of grasses and loss of leaves from deciduous live woody vegetation.
6. Modifies the 1-hour, 10-hour, 100-hour, and 1,000-hour fuel loads as a function of the Keetch-Byram Drought Index to account for the addition of fuel due to deep drying of litter and duff.
7. Does not change the procedure for adjusting the live herbaceous load. It is the same as when using a 1978 fuel model set with 1978 style weather.
8. Increases the deciduous live woody load in the spring and decreases it in the fall (after a freeze) over a period equal to the climate class times 7 days.

Running a 1988 fuel model set with the 1988 style of weather data:

1. Allows the fire manager the option to set the fine fuel moisture equal to the 10-hour fuel moisture. Even if the fire manager does not select this option, FIRDAT will make the fine fuel moisture equal to the 10-hour fuel moisture on the day of and the day after more than 0.1 inch of precipitation.
2. Adjusts the 1988 wind reduction factor between minimum and maximum values as a function of the woody greenness factor. The wind reduction factor will vary only for the deciduous models.
3. Multiplies the wind reduction factor by 0.3 on the day of and the day after at least 0.1 inch of precipitation.
4. Does not alter the calculation procedures of the 100-hour, 1,000-hour, live woody, and live herbaceous moistures. They are the same as when running a 1978 fuel model set with 1978 style weather data.
5. Modifies the fine fuel load through curing of grasses and loss of leaves from deciduous, live woody vegetation.
6. Modifies the 1-hour, 10-hour, 100-hour, and 1,000-hour fuel loads as a function of the Keetch-Byram Drought Index to account for the addition of fuel due to deep drying of litter and duff.
7. Modifies the live woody and live herbaceous fuel moistures by their respective greenness factors.
8. Modifies the deciduous woody load and live herbaceous load by their respective greenness factors.
9. For the deciduous models, modifies the midflame windspeed as a function of the live woody greenness factor.

Running a 1978 fuel model set with the 1978 style of weather data (FIRDAT acts as though the 1988 NFDRS revisions never occurred):

1. Never makes the 1-hour fuel moisture equal to the 10-hour fuel moisture, even on the day of and the day after rain.

2. Does not adjust the wind reduction factor assigned to the 1978 fuel model.

3. Calculates all live and dead fuel moistures with the 1978 method.

4. Adjusts the fine fuel load by the addition of cured grass only.

5. Keeps the 10-hour, 100-hour, and 1,000-hour loads constant.

6. Modifies the live herbaceous load by the greening and curing of grasses and herbs; the fall curing process is instantaneous.

7. Keeps the live woody load constant.

Running a 1978 fuel model set with the 1988 style of weather data:

1. Never makes the 1-hour fuel moisture equal to the 10-hour fuel moisture even on the day of and the day after rain.

2. Does not adjust the wind reduction factor assigned to the 1978 fuel model.

3. Does not change the 100-hour and 1,000-hour fuel moisture calculations from those in the 1978 NFDRS.

4. Does not adjust either the live herbaceous or woody fuel moisture for the effect of drought.

5. Cures the live herbaceous and woody fuels instantly, not gradually.

6. Does not adjust the windspeed for the greenness factor or after precipitation.

7. Adjusts the fine fuel load for the curing of herbaceous fuels only.

8. Does not adjust the 10-hour, 100-hour, and 1,000-hour fuels for drought.

9. Does not adjust the live herbaceous and woody loads as a function of greenness factors.

APPENDIX V.– ABBREVIATIONS AND GLOSSARY

Abbreviations

BI	–Burning index
ERC	–Energy release component
FLI	–Fire load index
FM	–Fuel moisture
HCOI	–Human-caused fire occurrence index
HCR	–Human-caused risk
HCRSF	–Human-caused risk scaling factor
IC	–Ignition component
KDI	–Keetch-Byram Drought Index
LAL	–Lightning activity level
LOI	–Lightning fire occurrence index
LR	–Lightning risk
LRS	–Lightning risk scaling factor
NFDRS	–National Fire-Danger Rating System
SC	–Spread component
TL	–Timelag
1-hr TL FM	–1-hour timelag fuel moisture content
10-hr TL FM	–10-hour timelag fuel moisture content
100-hr TL FM	–100-hour timelag fuel moisture content
1,000-hr TL FM	–1,000-hour timelag fuel moisture content

Glossary

Adjective class matrix.–The table that combines the manning classes (usually based on the BI) with the IC to specify the standard levels of fire danger for public information.

Burning index (BI).–An NFDRS value related to the contribution of fire behavior to the effort of containing a fire. The BI measures fire intensity (BI = 10 x flame length).

Components of the NFDRS.–Components include ignition, spread, and energy release.

Cumulative departure.–The sum of the daily departures (usually for a year).

Cumulative frequency.–The sum of all of the frequencies up to and including this one.

Daily departure.–The numerical difference between the daily value of the variable and the 90th percentile value of that variable when the daily value is greater than the 90th percentile value.

Energy release component (ERC).–A number related to the available energy (Btu) per unit area (square foot) within the flaming front at the head of a fire.

FIRDAT.–A routine of FIREFAMILY that combines historical weather records with the equations of the NFDRS to produce frequency distributions of the NFDRS indexes and components.

Fire-danger rating area.–A geographical area within which the fire danger can be assumed to be uniform. It is relatively homogeneous in climate, fuels, and topography.

FIREFAMILY.–A computer program that uses historical weather data for fire planning. Its three major routines are FIRDAT, SEASON, and FIRINF.

Fire load index (FLI).–A rating of the maximum effort required to contain all probable fires occurring within a rating area during the rating period.

Fire season.–A period during which weather and fuels are conducive to wildfires. (Also, see split fire season.)

FIRINF.–A routine of FIREFAMILY that uses data from FIRDAT to create tables of combinations of two NFDRS indexes and components.

Frequency (also relative frequency).–Proportion of occurrences of a value at a particular numerical level compared with all occurrences.

Fuel model.–A simulated fuel complex for which all the fuel descriptors required by the mathematical fire spread model have been specified.

Fuel moisture content (also fuel moisture) (FM).–The water content of a fuel particle expressed as a percent of the ovendry weight of the fuel particle. The six NFDRS fuel moistures are woody, herbaceous, 1-hour, 10-hour, 100-hour, and 1,000-hour.

Header page.–The first page of output, which repeats the user-supplied lead card information.

Herb.–A plant that does not develop woody, persistent tissue but is relatively soft or succulent and sprouts from the base (perennials) or develops from seed (annuals) each year. Included are grasses, forbs, and ferns.

Herbaceous fuels.–Undecomposed material, living or dead, derived from herbaceous plants.

Herbaceous greenness factor.–A number from 0 through 20 that indicates the relative level of herbaceous greenness. Zero indicates fully cured, while 20 indicates the grass is as green as it ever gets. The fire weather observer enters intermediate values during the spring greening process, the fall curing, or during drought periods when plants are under significant moisture stress.

Human-caused fire occurrence index (HCOI).–A rating value formed by combining HCR with today's IC. It is related to the expected number of reported wildfires in the rating area.

Human-caused risk (HCR).–A number related to the expected number of human-produced firebrands capable of starting fires that a rating area will be exposed to during the rating period.

Human-caused risk scaling factor (HCRSF).–A number relating human-caused fire incidence to the IC on a rating area. The factor is a statistic based on 3 to 5 years of fire occurrence and fire weather data that adjusts the prediction of the basic human-caused fire occurrence model to fit local experience.

Ignition component (IC).–The rating of the probability that a firebrand will cause a wildfire requiring suppression action.

Indexes of the NFDRS.–Human-caused fire occurrence, lightning-caused fire occurrence, burning, and fire load.

Job runstream.–See runstream.

Keetch-Byram Drought Index (KDI).–A number that has a direct relationship to drought stress. It is expressed from 0 to 800 with 800 being the maximum stress.

Lead card.–The user-supplied part of the job runstream that provides information and chooses options for the FIREFAMILY program.

Lightning activity level (LAL).–A numerical rating of 1 to 6, keyed to the start of thunderstorms and the frequency and character of cloud-to-ground lightning, forecast or observed on a rating area during the rating period.

Lightning fire occurrence index (LOI).–A numerical rating of the potential occurrence of lightning-caused fires.

Lightning risk (LR).–A number related to the expected number of cloud-to-ground lightning discharges capable of starting fires that a rating area will be exposed to during the rating period.

Lightning risk scaling factor (LRS).–A factor derived from local thunderstorm and lightning-caused fire records that adjusts the predictions of the basic lightning fire occurrence model to local experience. It accounts for factors not addressed directly by the model such as susceptibility of local fuels to ignition by lightning, fuel continuity, topography, and regional characteristics of thunderstorms.

Manning classes (also manning levels).–The minimum strength of forces which an agency plans to activate at each level of fire danger.

Matrix.–As used in this publication, another word for table.

Passing file.–A product of FIREFAMILY that saves FIRDAT data for later use with SEASON and/or FIRINF.

Persistence probability.–As used in this publication, the fraction of the time that the weather will remain the same 2 days in a row.

Precautions class matrix.–A table (used principally in the USDA Forest Service Region 6, the Pacific Northwest) that uses the ERC or the BI with the IC. One use of the precautions class matrix is to regulate industrial forest usage.

Relative frequency.–See frequency.

Runstream (also job runstream).–Series of control cards used at Fort Collins to run FIREFAMILY.

Season.—A routine of FIREFAMILY that uses FIRDAT's results to tabulate and graph one NFDRS index, component, or fuel moisture at a time to show seasonal weather patterns.

Season of the year.–An important entry for calculating live fuel moistures in the 1988 NFDRS. Coded numerically as 1–winter, 2–spring, 3–summer, and 4–fall.

Split fire season.–Two or more periods of many wildfires separated by a period of few fires.

Spread component (SC).–A rating of the forward rate of spread of a head fire expressed in feet per minute.

Variable.–As used in this publication, any of the NFDRS indexes or components. In FIRDAT and SEASON, fuel moistures are also considered variables.

Woody greenness factor.–A number from 0 through 20 that indicates the relative level of shrub greenness. Zero indicates that all the leaves have fallen off deciduous shrubs or that evergreen shrubs are dormant. Twenty indicates the shrub leaves are fully developed and not under moisture stress. The fire weather observer enters intermediate values during the spring greening process, the fall curing, or during drought periods when plants are under significant moisture stress.

☆U.S. GOVERNMENT PRINTING OFFICE: 1990–756–337/153

Main, William A.; Paananen, Donna M.; Burgan, Robert E.
1990. **FIREFAMILY 1988**. Gen. Tech. Rep. NC-138. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 35 p.

This revised user's guide will help fire managers interpret the output from FIREFAMILY, a computer program that uses historic weather data for fire planning. With the changes in the National Fire-Danger Rating System, all Forest Service units will need to rerun their historical weather data and use this publication to revise their fire plan. The guide describes options within the program and explains various tables and graphs necessary for planning. It also provides computer specialists with details needed to run the program.

KEY WORDS: Fire weather, fire danger, National Fire-Danger Rating System, fire planning, historic weather data

Our job at the North Central Forest Experiment Station is discovering and creating new knowledge and technology in the field of natural resources and conveying this information to the people who can use it. As a new generation of forests emerges in our region, managers are confronted with two unique challenges: (1) Dealing with the great diversity in composition, quality, and ownership of the forests, and (2) Reconciling the conflicting demands of the people who use them. Helping the forest manager meet these challenges while protecting the environment is what research at North Central is all about.